US Evaluation and Clinical Applications of AVF and AVG for Hemodialysis Access

1. Fundamentals of Hemodialysis Access

End-stage renal disease (ESRD) is a growing global health burden, and hemodialysis remains the most widely used form of renal replacement therapy. Vascular access is the lifeline of hemodialysis, and its three main types — arteriovenous fistula (AVF), arteriovenous graft (AVG), and tunneled central venous catheter — each carry distinct advantages, limitations, and clinical indications. The knowledge of upper extremity vascular anatomy is essential, including the radial, ulnar, and brachial arteries, as well as the cephalic, basilic, and median cubital veins, as these structures form the basis of access planning and sonographic evaluation.

2. Pre-operative Vascular Mapping

Pre-operative ultrasound vascular mapping plays a decisive role in surgical planning by guiding the choice of access type and operative site. Arterial assessment includes evaluation of luminal diameter, wall calcification, compressibility, and Doppler waveform characteristics. Venous assessment addresses diameter, patency, distensibility, and continuity from the wrist to the axilla. Practical aspects of the examination are also covered, including patient preparation, limb positioning, tourniquet use for venous distension, and standardized reporting to facilitate clear communication with the surgical team.

3. US Evaluation of Mature AVF and AVG

AVF maturation is usually assessed using the "Rule of 6s," which requires a flow volume ≥600 mL/min, access diameter ≥6 mm, and depth ≤6 mm from the skin surface. Normal Doppler appearances of a mature fistula include characteristic low-resistance waveforms, expected velocity ranges, and volume flow calculation methodology. Common AVF configurations — radiocephalic, brachiocephalic, and brachiobasilic — are reviewed with attention to their respective anatomical and sonographic features. For AVG, the normal sonographic appearance of synthetic graft material is compared to native fistulae, with discussion of expected Doppler flow patterns within the graft body, arterial anastomosis, and venous anastomosis. Key differences in maturation timeline and surveillance

requirements between AVF and AVG are also highlighted.

4. Complications: Stenosis, Thrombosis, Steal Syndrome, Pseudoaneurysm, and Infection

Stenosis most commonly occurs at the juxta-anastomotic segment in AVF and at the venous anastomosis in AVG. Doppler criteria for diagnosis include peak systolic velocity thresholds and velocity ratios across the stenotic segment. Thrombosis is evaluated in terms of acute versus chronic presentation, with color and spectral Doppler used to confirm absent or markedly diminished flow and to distinguish partial from occlusive thrombus. Steal syndrome results from hemodynamic diversion of blood away from the distal extremity, and its key sonographic finding is reversal of arterial flow distal to the anastomosis during systole, interpreted alongside clinical signs of digital ischemia. Pseudoaneurysm — particularly relevant in AVG — is characterized by the yin-yang color flow pattern and to-and-fro waveform on spectral Doppler, and criteria for distinguishing it from true aneurysmal dilation in native AVF are discussed. Access-related infection and perigraft fluid collection are identified by sonographic features including abscess formation, perigraft fluid, and graft wall irregularity, always interpreted within the appropriate clinical context.

5. Surveillance and Clinical Decision-Making

Surveillance of hemodialysis access includes both routine scheduled monitoring and indication-based assessment triggered by clinical warning signs such as elevated venous dialysis pressures, prolonged post-needling hemostasis, decreased Kt/V, or poor blood flow during dialysis sessions. Access flow volume serves as the primary surveillance parameter, with intervention generally considered when flow falls below 500–600 mL/min in AVF. When significant stenosis or hemodynamic compromise is identified, referral for fistulogram, percutaneous transluminal angioplasty (PTA), or surgical revision is warranted. Hemodialysis access care is inherently multidisciplinary, and the radiologist and sonographer play a central role within the nephrology and surgical team in prolonging access longevity and optimizing patient outcomes.