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Ensuring Quality in Hemodialysis: from Adequacy to Outcomes

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Dialysis adequacy has historically been defined by small-solute clearance, particularly Kt/V_{urea} , following landmark studies such as the National Cooperative Dialysis Study and the HEMO trial. While these metrics remain central to clinical practice, accumulating evidence suggests that achieving target Kt/V alone does not adequately reflect the complexity of patient care or translate into meaningful improvements in survival and quality of life in patients with end-stage kidney disease (ESKD). Contemporary perspectives increasingly emphasize that dialysis adequacy should extend beyond urea kinetics to encompass a broader, multidimensional framework. Patients undergoing maintenance hemodialysis continue to experience high rates of cardiovascular morbidity and mortality, driven by multiple interrelated factors including fluid overload, inadequate removal of middle molecules, and loss of residual renal function (RRF). Traditional adequacy metrics fail to account for these important determinants. In particular, middle molecules such as β_2 -microglobulin exhibit slower intercompartmental kinetics and require convective strategies for effective clearance, highlighting the limitations of diffusion-based therapies alone. Recent advances in dialysis technology have focused on enhancing the removal of a wider spectrum of uremic toxins while improving hemodynamic stability and patient-centered outcomes. High-volume online hemodiafiltration (HDF), which combines diffusive and convective clearance, has shown promising results in both observational studies and randomized controlled trials. Notably, the CONVINCe trial demonstrated a significant reduction in all-cause mortality among patients treated with high-dose HDF compared to conventional high-flux hemodialysis. In addition to survival benefits, HDF has been associated with improved intradialytic stability and quality of life. Expanded hemodialysis (HDx) using medium cut-off membranes represents

another innovative approach, enabling enhanced removal of large middle molecules while maintaining albumin levels. Although HDx has demonstrated favorable effects on symptom burden, physical functioning, and cardiovascular-related outcomes, consistent evidence for mortality reduction remains limited. In this evolving landscape, dialysis adequacy should be redefined as a comprehensive concept integrating solute clearance, volume management, preservation of RRF, cardiovascular protection, and patient-reported outcomes. Advanced modalities such as HDF and HDx offer important opportunities to improve clinical outcomes and should be considered as part of individualized, patient-centered dialysis strategies.

Keywords: hemodialysis, ESKD, quality, adequacy