



Clinical challenges and individualized approaches to dialysis therapy in older adults

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Global population aging has substantially increased in the number of older adults who undergo kidney replacement therapy (KRT). Age-related physiological changes and functional dependence in this population lead to the multifaceted clinical and ethical challenges associated with KRT. Geriatric syndromes, including functional impairment, frailty, malnutrition, and multimorbidity, can influence the choice of dialysis modality and modify dialysis prescriptions, often resulting in patients requiring assistance with dialysis implementation. Although dialysis remains a key life-sustaining therapy, the limited life expectancy and multiple comorbidities of older adults increase the risk of adverse outcomes, supporting the consideration of conservative kidney management as an alternative. Furthermore, because many older adults prioritize quality of life and reduced treatment burdens over longevity and biochemical targets, dialysis-related decisions should be tailored to individual preferences and goals. Shared decision-making involving older patients, their caregivers, healthcare professionals, and nephrologists is essential for determining the most appropriate treatment approach. This review addresses the clinical considerations in decision-making regarding dialysis and proposes optimal treatment strategies tailored to the unique needs of older patients with chronic kidney disease.

Keywords: Aged; Dialysis; Frailty; Geriatric assessment

INTRODUCTION

As the global population continues to age, the incidence of end-stage kidney disease (ESKD) among older adults has increased in many countries [1,2]. Most of them require kidney replacement therapy (KRT), such as dialysis or kidney transplantation. However, older adults are generally not considered suitable candidates for kidney transplantation, resulting in a gradual increase in the number of older patients undergoing dialysis. According to the Korean Renal Data System (KORDS), patients aged ≥ 65 years have accounted for more than half of the total dialysis population in Korea since 2018 [3]. Older patients undergoing dialysis have a high prevalence of adverse clinical outcomes.

From 2013 to 2023, hospitalization rates were the highest among individuals aged ≥ 75 years, and all-cause mortality increased in this group while it declined in younger populations [4]. These trends highlight the growing importance of individualized management strategies for older adults undergoing dialysis.

Physiological age with well-preserved physical function is likely more clinically relevant than chronological age or longevity for quality of life in older patients [5]. Collectively, frailty, malnutrition, and multimorbidity are used to define the physiological age of older adults. In older adults requiring dialysis, these age-related conditions can influence the choice of dialysis modality and lead to changes in dialysis prescriptions as well as often result in patients requiring as-

sistance with treatment implementation. Therefore, physicians play a key role in supporting older patients in making decisions about dialysis initiation and modalities and establishing treatment strategies tailored to patients' clinical status. This review addresses clinical considerations in dialysis decision-making and proposes optimal treatment strategies tailored to the unique needs of older patients with chronic kidney disease (CKD). This review focuses primarily on issues related to dialysis therapy in the treatment management of older adults with ESKD, with the exception of kidney transplantation.

INITIATION OF DIALYSIS THERAPY IN OLDER PATIENTS

Decision to initiate dialysis therapy

In general, dialysis improves both the quality of life and survival of patients with advanced CKD compared to conservative management [6,7]. However, several studies have found that the survival benefit of dialysis over conservative management tends to disappear in patients aged > 80 years [6,7]. Early mortality within the first 120 days after hemodialysis (HD) initiation remains higher in older patients than in younger patients [8]. In older adults with limited life expectancy, dialysis may not offer a survival benefit and could be potentially harmful. In this context, conservative kidney management (CKM), in which supportive care and symptom-focused treatment are provided without dialysis, may be an alternative for older adults with limited life expectancy [9]. Therefore, whether CKM or dialysis is more appropriate

for older patients with limited life expectancy who require KRT must be determined.

Prediction tools and scoring systems can help guide risk stratification for mortality and progression to ESKD in older patients with CKD stages 3b–5 and support individualized decision-making for KRT initiation. In 2017, the European Renal Best Practice (ERBP) guidelines recommended a step-wise approach using validated tools to estimate kidney failure and mortality risks (Fig. 1, Supplementary Table 1) [10]. This framework advises physicians to assess both the 5-year mortality risk using Bansal scores and the risk of progression to kidney failure using the Kidney Failure Risk Equation (KFRE) [11,12]. When the mortality risk is high, CKM is generally considered more appropriate than KRT. Conversely, a high KFRE score combined with a low mortality risk may support early preparation for KRT, whereas a low KFRE score favors continued nephroprotective care without immediate KRT. When patients are expected to initiate KRT within 3–6 months, their Renal Epidemiology and Information Network scores can be used to estimate short-term mortality after dialysis initiation, helping physicians and patients more accurately weigh the potential benefits and burdens of dialysis [13]. However, these models and guidelines were developed based on European cohorts and have not been specifically adapted for use in Korean clinical settings. To address this issue, To address this issue, the Korean Society of Geriatric Nephrology recently developed a 6-month mortality prediction model for patients aged ≥70 years requiring HD, using data from a multicenter retrospective cohort including 16 institutions in Korea [14]. Further development of prediction models based on Korean data could improve clinical deci-

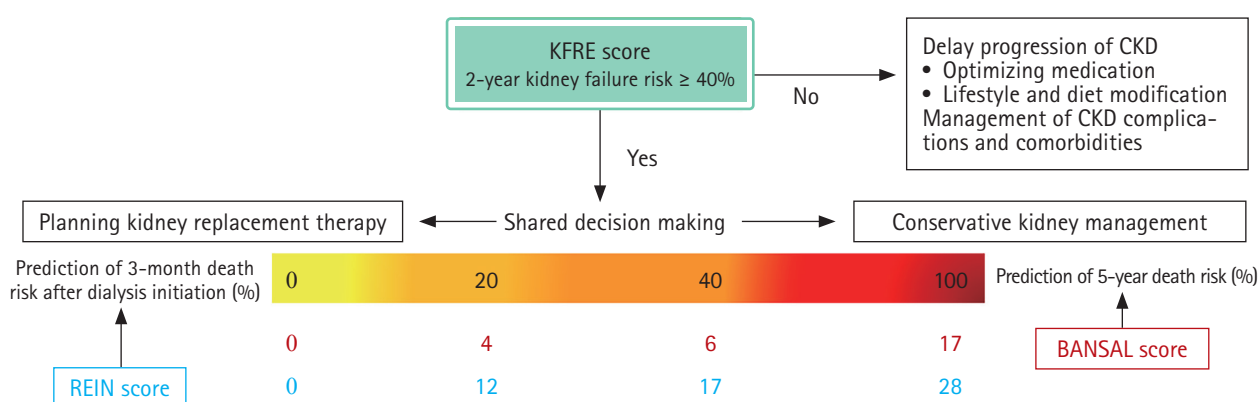


Figure 1. Decision to initiate kidney replacement therapy in older patients with advanced CKD based on the 2017 ERBP guidelines. CKD, chronic kidney disease; KFRE, Kidney Failure Risk Equation; REIN, Renal Epidemiology and Information Network; ERBP, European Renal Best Practice.

sion-making and support dialysis planning tailored to the older Korean population.

The preferences of older patients and their caregivers are important when deciding whether to initiate dialysis. Although dialysis is a vital life-sustaining therapy, it can cause burdens and adverse effects, such as fatigue, repeated needle punctures, frequent hospitalizations, and high maintenance costs [15]. Some older patients with advanced CKD prioritize their care goals and values over longevity and prefer CKM to avoid complications. In addition, caregivers of older patients, who are usually family members, play a key role in the decision-making process for dialysis because they share patients' physical, psychological, and financial burdens [16]. They provide practical support for peritoneal dialysis (PD), assist with transportation to HD units, and often act as primary decision-makers for older patients with cognitive impairment. Therefore, shared decision-making (SDM) involving patients, caregivers, and healthcare providers is essential throughout the course of treatment from the initiation of dialysis to its maintenance and withdrawal. SDM can help close medical information gaps among patients, caregivers, and clinicians, support patient-centered decisions, and promote patients' decisional autonomy [17].

Timing of dialysis initiation

Age is a well-established risk factor for unplanned dialysis because older patients tend to delay decisions regarding dialysis initiation and fail to achieve mature vascular access (VA) [18]. Unplanned dialysis initiation in older adults is associated with higher mortality and hospitalization risks [19,20]. Therefore, accurate prediction of progression to kidney failure and timely initiation of dialysis are essential for older patients.

Accurate assessment of kidney function in older patients is essential to determine the optimal timing of dialysis. However, serum creatinine levels and uremic symptoms may not be reliable indicators of kidney failure in this population. Serum creatinine has inherent limitations as a marker of glomerular filtration because non-glomerular filtration rate (GFR) determinants, such as muscle mass, tubular secretion, and dietary intake, influence its accuracy. In older patients with frailty and sarcopenia, estimated GFR (eGFR) is overestimated due to reduced muscle mass and low creatinine levels. Given these limitations, the 2024 Kidney Disease: Improving Global Outcomes (KDIGO) clinical practice guidelines recommend using the combined creatinine-cystatin C

equation (eGFR_{cr-cys}) in clinical situations in which creatinine generation is reduced due to low muscle mass or creatinine secretion or extrarenal elimination is altered by specific medications [21]. Therefore, the eGFR_{cr-cys} equation is recommended for assessing kidney function in older adults.

The KDIGO 2024 clinical practice guidelines recommend that decisions regarding dialysis initiation be based on a composite assessment of uremic symptoms and signs, quality of life, preferences, kidney function, and laboratory abnormalities [21]. The guidelines emphasize that clinical circumstances that require dialysis initiation typically occur when eGFR falls between 5 and 10 mL/min/1.73 m². However, the decision should primarily be guided by clinical signs, symptoms, and overall patient condition rather than eGFR alone. Assessment of uremic symptoms in older patients is particularly challenging. Symptoms such as cognitive impairment, fatigue, anorexia, and pruritus are often subjective and nonspecific in this population. Furthermore, these symptoms can overlap with comorbidities commonly observed in older adults, including cardiovascular disease, neurocognitive disorders, and psychiatric conditions, making true uremic manifestations difficult to distinguish. Therefore, careful clinical observation and differentiation of uremic signs and symptoms from those related to other comorbidities are essential when considering dialysis initiation in older adults.

Selection of dialysis modality

HD and PD have no absolute contraindications, except when VA cannot be established or the peritoneal membrane is nonfunctional in older patients. In general, dialysis modality selection is based on comorbidities, occupational and lifestyle factors, and the need to preserve residual kidney function (RKF). In older adults, additional factors such as functional impairment, multiple comorbidities, and familial support should be considered because they may further influence the advantages and disadvantages of each modality.

The advantages of PD include RKF preservation, feasibility of home-based dialysis, and improved cardiovascular stability. However, functional impairments associated with frailty and aging may increase the risk of peritonitis, particularly in relation to malnutrition and difficulties in performing PD procedures [22,23]. Poor performance status often prevents older adults from performing PD independently; thus, they require caregiver assistance. Regarding HD, patients benefit from prompt medical attention from physicians and can

maintain social relationships through regular hospital visits. However, HD requires patients and their caregivers to spend additional time and financial costs on transportation to dialysis facilities. Moreover, older adults, especially those with cardiovascular disease or impaired immune function, are vulnerable to intradialytic hypotension (IDH) and dialysis-related bloodstream infections.

In older patients with ESKD, the effects of dialysis modality on mortality risk must be considered when making appropriate treatment decisions [24]. A recent meta-analysis revealed that PD has a higher mortality rate than HD in patients aged ≥ 60 years, particularly among those with diabetes, comorbidities, or prolonged dialysis duration. However, the difference in mortality risk between the two modalities appears to have diminished in studies conducted after 2010 [25]. Furthermore, a nationwide retrospective cohort study using data from the Korean National Health Insurance Service demonstrated that PD was associated with higher mortality rates than HD between 2004 and 2015 [26]. However, between 2012 and 2015, the mortality rate of PD became comparable to that of HD, regardless of age ≥ 65 years, diabetes status, or comorbidity burden. This improvement may be attributable to advancements in PD solutions and techniques and improvements in the management of cardiovascular complications.

In Korea, HD centers are unevenly distributed between urban and rural areas, and a substantial proportion of older patients live in rural areas. These patients often face a high risk of falls during transportation to HD facilities. Therefore, in older patients with a favorable physiological status who do not have diabetes or other major comorbidities, PD can be a practical and appropriate treatment strategy, particularly in Korean healthcare settings. Thus, an assisted PD system that provides a model of care in which trained healthcare personnel or caregivers support patients in performing PD at home needs to be established to increase PD adoption [27].

STRATEGIES FOR HEMODIALYSIS MANAGEMENT IN OLDER PATIENTS

Selection of vascular access

Arteriovenous fistula (AVF) is generally preferred over other types of VA because of its lower risks of complications, infection, and mortality, as well as superior patency compared to arteriovenous graft (AVG) [28,29]. Trends in VA creation

have shifted from the “fistula-first” approach outlined in the 2006 Kidney Disease Outcomes Quality Initiative (KDO-QI) guidelines to the “patient-first” approach in the updated 2019 guidelines [30]. The 2019 KDOQI guidelines recommend the use of a long-term central venous catheter (CVC) or AVG over AVF in patients with limited life expectancy or restricted vascular anatomy. Older adults frequently present with poor vascular anatomy and multiple comorbidities that contribute to reduced life expectancy. The 2023 KORDS showed that among older patients in Korea, the proportion of AVF tended to decrease with age, whereas those of AVG and CVC increased [4].

AVF is the preferred type of VA because of its superior long-term patency and lower complication rates. However, AVF requires a longer maturation period and is associated with a higher primary failure risk [31]. The high prevalence of diabetes, peripheral vascular disease, and anatomic restrictions makes older patients particularly vulnerable to primary failure of AVF [32]. The high risk of maturation failure may increase the likelihood of death before successful AVF use in older patients with limited life expectancy. In contrast, a CVC-only strategy enables prompt dialysis initiation and avoids unnecessary procedures related to arteriovenous (AV) access (Table 1). Furthermore, AVG allows for early cannulation to ensure timely dialysis initiation and serves as a catheter-sparing option [33,34]. Therefore, CVC and AVG may be more suitable than AVF for older patients with a limited life expectancy who are at high risk for AVF failure.

Patients undergoing HD with CVC have poorer survival rates than those with other AV access [33,35,36]. However, a selection bias may be present in older patients. Older adults often remain dependent on CVCs without transitioning to AV access owing to their short life expectancy and multiple comorbidities. Thus, their lower survival rates may not be entirely attributable to CVC use [37]. A retrospective study from the Korean insurance claims data found that the mortality rate between AVF and AVG was not significantly different in patients aged ≥ 85 years [29]. Therefore, when treating older patients, nephrologists and vascular surgeons should take a patient-centered approach rather than strictly follow the “fistula-first” strategy in older patients.

Incremental hemodialysis

Almost all patients undergoing HD follow a standard thrice-weekly schedule from the start, whereas those undergoing PD typically adjust dialysis doses incrementally

Table 1. Clinical indications for long-term use of tunneled central venous catheters in older patients based on the 2019 KDOQI guidelines

- Anatomical restriction with high likelihood of maturation failure of AV access (diabetes, peripheral vascular disease, uncorrectable central venous occlusion, etc.)
- Limited life expectancy (< 1 yr) expected to be shorter than lead time to use AV access successfully
- Preexisting severe stages of heart failure vulnerable to deteriorate according to AV access flow (LVEF < 30%, NYHA class III/IV and ACC/AHA stage C/D, life-threatening pulmonary edema, etc.)
- Patient preference and clinical circumstances where AV access would limit their quality of life (needle phobia, bleeding diathesis, and dementia with risk of needle dislodgement)

AV, arteriovenous; ACC/AHA, American College of Cardiology and American Heart Association; KDOQI, Kidney Disease Outcomes Quality Initiative; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association.

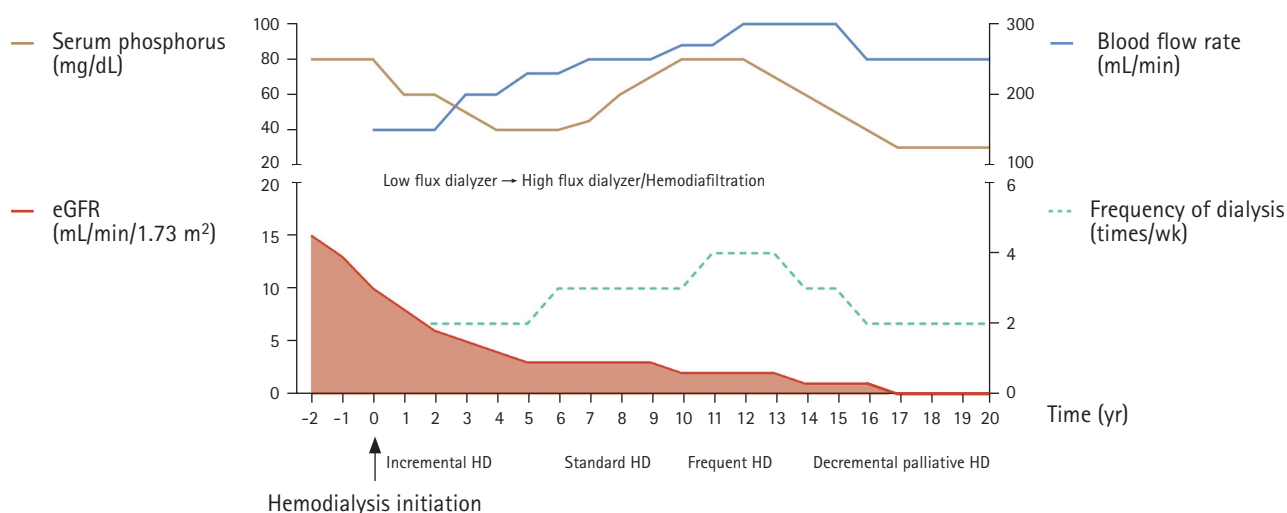


Figure 2. Schematic representation of the incremental HD approach with twice-weekly HD initiation. The diagram outlines a stepwise approach for initiating patients on a twice-weekly HD schedule. Patients begin with two sessions per week and ongoing monitoring of RKF, urine output, and clinical status. As RKF declines or clinical indications occur (e.g., volume overload, hyperphosphatemia, and hyperkalemia), HD frequency is gradually increased to three times per week. This approach also includes decremental palliative hemodialysis for patients with limited life expectancy, focusing on symptom relief and quality of life rather than achieving conventional dialysis adequacy targets. eGFR, estimated glomerular filtration rate; HD, hemodialysis; RKF, residual kidney function.

based on a decline in RKF [38]. RKF gradually declines after dialysis initiation, regardless of modality; therefore, an approach similar to “incremental HD” can be applied to PD. In incremental HD, dialysis starts at a reduced dose, such as twice-weekly or three hours per session, and gradually increases to the standard thrice-weekly, four hours per session, to compensate for progressive RKF loss (Fig. 2) [39]. Furthermore, the prescriptions of the size of dialyzer membrane, dialysate volume, and blood flow rate can be adjusted over time to maintain dialysis adequacy.

The incremental HD strategy may be suitable for older patients with low dietary intake and interdialytic weight gain (IDWG) because preserved RKF can compensate for skipped

or shortened dialysis sessions. An incremental approach allows older patients to adjust gradually to the dialysis procedure and its associated complications, such as post-dialysis fatigue and muscle cramps. Furthermore, it reduces the frequency of hospital visits, thereby alleviating the burden on both patients and their caregivers, particularly for patients without a nearby HD facility.

Two pilot randomized controlled trials (RCTs) reported that incremental HD preserves RKF and reduces hospitalization rates without deteriorating metabolic derangements or increasing mortality compared with standard thrice-weekly HD in incident patients with RKF undergoing HD [40,41]. However, these studies did not specifically focus on older

patients. In Korea, a pragmatic RCT has been underway since November 2021 to compare clinical outcomes, including mortality, hospitalization, and quality of life, between incremental HD with an initial twice-weekly schedule and conventional thrice-weekly HD in incident HD patients aged ≥ 60 years [42]. The findings from this and other ongoing RCTs are expected to support the clinical benefits and feasibility of an individualized approach to incremental HD in older patients (Table 2) [43-47].

Timely adjustments to the HD dose according to the patient's decline in RKF are essential to prevent underdialysis. This requires regular assessment of RKF through urea clearance and other biomarkers, close monitoring of nutritional and fluid status, ongoing evaluation of patient adherence to dialysis schedules, and proactive patient education, especially for older adults, on the risks of underdialysis and the need for dose escalation [39].

Prescription of hemodialysis

Dry weight is defined as the lowest post-dialysis body weight tolerated without signs of hypovolemia [48]. The high prevalence of cardiovascular disease and autonomic dysfunction indicates that older patients are vulnerable to circulatory stress and volume changes during HD. Inappropriate titration of dry weight can increase the risk of IDH [48,49], which is associated with adverse outcomes, including post-dialysis fatigue, dialysis interruption, RKF decline, multi-organ ischemia, and mortality [50-52]. Recurrent IDH can also lead to cerebral hypoperfusion and worsening cognitive impairment in older patients [53,54]. Common strategies to prevent IDH include limiting IDWG and optimizing the target dry weight [48]. Dietary restriction is a feasible approach for reducing IDWG at the patient level. However, the risk of malnutrition must be carefully considered when treating older patients. Physicians should avoid setting the dry weight excessively low without properly assessing volume status. Instead, careful evaluation of fluid balance and individualized dry weight adjustment are essential, particularly when managing comorbidities in older patients.

HD adequacy is typically assessed based on urea clearance, expressed as Kt/V, which reflects the removal of small solutes. Clinical guidelines recommend a target single-pool (sp) Kt/V greater than 1.4, with a minimum delivered spKt/V of 1.2 [55]. However, age-related changes in body composition should be considered when interpreting Kt/V in older patients. Older adults often have lower muscle mass relative

to total body mass than younger people, making their actual fluid volume smaller than the estimated distribution volume and leading to the potential underestimation of Kt/V. Consequently, older patients may receive unnecessarily high dialysis doses, increasing their exposure to HD-related materials and the risk of adverse events without clear clinical benefits [56,57]. A recent Korean study found that achieving a Kt/V greater than 1.4 did not provide additional survival benefits in patients aged ≥ 85 years [58]. In older patients undergoing HD, survival is closely associated with systolic blood pressure, mineral metabolism, nutritional status, and cardiovascular comorbidities [59]. Therefore, the adequacy of HD in older patients should be assessed through a comprehensive evaluation of clinical parameters, in addition to urea clearance.

Middle molecule clearance is another important indicator of HD adequacy. High-flux dialyzers and hemodiafiltration (HDF) provide superior clearance of middle molecules compared to low-flux dialyzers [60]. However, low-flux dialyzers are often preferred in older patients because they can achieve Kt/V targets while minimizing mineral and nutrient loss [61]. The accumulation of middle molecules can lead to adverse clinical outcomes such as dialysis-related amyloidosis and cardiovascular mortality [62,63]. Several studies have demonstrated the clinical advantages of high-flux HD and HDF in older patients. Huang et al. [64] found that high-flux HD had a lower risk of cardiovascular mortality compared with low-flux HD in older patients. A recent RCT showed that high-dose HDF with a convection volume of at least 23 L per session provides a survival benefit over high-flux HD, but only in patients aged ≥ 65 years [65]. Another RCT that included patients aged ≥ 65 years demonstrated that HDF was associated with a lower risk of asymptomatic IDH compared with high-flux HD, although health-related quality of life, morbidity, and mortality were similar between groups [66]. Therefore, when prescribing HD for older patients, nephrologists should prioritize comprehensive clinical benefits beyond laboratory targets for dialysis adequacy. Accordingly, high-flux HD and HDF may be favorable treatment options.

Table 2. Overview of completed and ongoing randomized controlled trials comparing incremental and conventional HD

Study	Country	Target sample	Study participants	Follow-up duration	Residual kidney function eligibility/Actual residual kidney function	Outcome	Results
PRIDE [42]	Republic of Korea	428	Twice-weekly HD vs. Thrice-weekly HD Age ≥ 60 yr	24 mo	UO ≥ 500 mL/day	Primary outcome: all-cause hospitalization Secondary outcome: dialysis-related hospitalization rate, length of hospital day, mortality rate, and quality of life	In progress
TWOPLUS [40]	United States	50	Twice-weekly HD for 6 wk followed by thrice-weekly at week 7 (n = 23) vs. Thrice-weekly HD (n = 25) Mean age: 61.3 ± 14.0	12 mo	KrU ≥ 5 mL/min/1.73 m ² Urine output ≥ 500 mL/day /24-h urine volume (mL/day): Twice-weekly HD group: 914 ± 522 Thrice-weekly HD: 1,424 ± 955	Primary outcome: feasibility Secondary outcome: RKF (24-h urine volume, urea clearance, creatinine clearance, total urea clearance, and volume status)	Incremental HD group vs. conventional HD group Percentage change in urine volume from baseline to week 24: +22.8 vs. -28.2 (estimated difference of 51.0 (-0.7 to 102.8)) Percentage change in average renal urea and creatinine clearance from baseline to week 24: +12.4 vs. -45.5
Impact of incremental versus conventional initiation of hemodialysis on residual kidney function [41]	United Kingdom	54	Twice-weekly HD for 3.5–4 h (n = 29) vs. Thrice-weekly HD for 3.5–4 h (n = 26) Mean age: Incremental HD: 61.4 ± 15.2 vs. Standard HD: 63.1 ± 12.3	12 mo	KrU ≥ 3 mL/min/1.73 m ² / Twice-weekly HD group: 4.41 (4.00–5.69) Thrice-weekly HD group: 4.21 (3.65–5.17)	Primary outcome: feasibility, change in RKF (BSA-corrected GFR slope), and hospitalization rate related to dialysis complications Secondary outcome: frailty, quality of life, cognitive function, and biochemistry	Incremental HD group vs. conventional HD group Hospitalization events: IRR 0.31 (0.17–0.59, p < 0.001) Change in RKF (mL/min/1.73 m ²): -0.32 ± 0.38 vs. -0.08 ± 0.51 (p = 0.07)
IHDIP [43]	Spain	152	Once a week HD vs. Thrice-weekly HD	24 mo	KrU ≥ 4 mL/min/1.73 m ²	Primary outcome: survival Secondary outcome: hospitalization rate, RKF preservation, HD adequacy, biochemistry, and quality of life	In progress

Table 2. Continued

Study	Country	Target sample	Study participants	Follow-up duration	Residual kidney function eligibility/Actual residual kidney function	Outcome	Results
REAL LIFE [44]	Italy and Poland	116	Once-weekly HD vs. Thrive-weekly HD	24 mo	KrU between 5 and 10 mL/min/1.73 m ² UO ≥ 600 mL/day	Primary outcome: loss of RKF, defined as UO ≤ 200 mL/day Secondary outcome: survival, biochemistry, and composite cardiovascular events	In progress
Initiating renal replacement therapy through incremental hemodialysis [45]	Spain	88	Twice-weekly HD vs. Thrive-weekly HD	12 mo	KrU ≥ 2.5 mL/min/1.73 m ²	Primary outcome: loss of RKF, defined as UO < 100 mL/day Secondary outcome: mortality, hospitalization rate, biochemistry, HD adequacy, and quality of life	In progress
INCH-HD [46]	Australia and Canada	372	Twice-weekly HD vs. Thrive-weekly HD	18 mo	UO ≥ 500 mL/day	Primary outcome: health-related quality of life (KDQOL-SF) Secondary outcome: RKF, mortality, MACE, and hospitalization rate	In progress
INCHVETS [47]	United States	252	Twice-weekly HD vs. Thrive-weekly HD	12 mo	UO ≥ 500 mL/day and KrU > 3 mL/min	Primary outcome: health-related quality of life (SF-36) Secondary outcome: RKF, HD adequacy, and dialysis symptoms	In progress

BSA, body surface area; GFR, glomerular filtration rate; HD, hemodialysis; IRR, incidence rate ratio; KDQOL-SF, Kidney Disease Quality of Life Short Form; KrU, residual urea clearance rate; MACE, major adverse cardiovascular events; RKF, residual kidney function; UO, urine output.

STRATEGIES FOR PERITONEAL DIALYSIS MANAGEMENT IN OLDER PATIENTS

Incremental peritoneal dialysis

Many centers have adopted incremental PD as an initial PD strategy since its introduction in the 1990s [67,68]. In incremental PD, the initial PD dose is lower than the standard full dose, but achieves target clearance with the support of RKF. Then, the dose is progressively increased as RKF declines [69]. For example, an incremental approach to continuous ambulatory peritoneal dialysis begins with three 1.5-L exchanges per day, with a gradual increase to the standard four 2-L exchanges as RKF declines. In automated peritoneal dialysis (APD) using a cycler, treatment starts with three 1.5-L nighttime exchanges, without daytime dwell. As RKF deteriorates, the dwell volume can be increased or daytime dwell can be added. In addition, PD can be prescribed for fewer than seven days per week by incorporating “PD holidays” during which dialysis is not performed (Table 3).

Incremental PD offers several advantages over standard full-dose PD, including better RKF preservation, reduced glucose exposure, and lower peritonitis risk [70]. Compared with standard PD, incremental PD is associated with superior technique survival, defined as a lower likelihood of transfer from PD to HD because of complications such as peritonitis, catheter dysfunction, or peritoneal membrane failure [71]. The 2020 International Society of Peritoneal Dialysis (ISPD) guidelines recommend modifying PD prescriptions to minimize the treatment burden on frail and older patients [72]. Incremental PD supports this strategy by requiring fewer PD exchanges and shorter dwell times during the early treatment phase. Thus, it enables older patients to gradually adapt to life with PD and offers them greater flexibility in daily life.

The 2020 ISPD guidelines highlight a paradigm shift from traditional adequacy targets based solely on small solute clearance to a goal-directed, person-centered approach to PD [72]. This approach emphasizes a comprehensive assessment that includes not only solute clearance but also laboratory parameters, nutritional status, and health-related quality of life. Therefore, alternative PD strategies, such as decremental PD and low-clearance non-incremental PD, may be appropriate for older patients. Decremental PD gradually reduces the volume and number of exchanges in response to changes in the patient’s clinical condition, taking an approach opposite to that of incremental PD. This

strategy may be suitable for older patients who only require relief from uremic symptoms and are not aiming for specific clearance targets due to life expectancy or intractable illnesses. Low-clearance non-incremental PD delivers a lower dose than standard full-dose PD during the early phase. Unlike in incremental PD, the dose is not increased because the initial prescription meets low metabolic demands, particularly in older patients with low muscle mass and poor dietary intake.

Assisted peritoneal dialysis

Functional dependence has frequently been a barrier to PD eligibility for older patients. Decreased vision, reduced hand coordination, and cognitive dysfunction can interfere with the precise handling of PD equipment, potentially leading to adverse clinical outcomes [73,74]. Assisted PD, which involves support from family members, nurses, or paid caregivers, has allowed many older patients to become eligible for PD [75]. These caregivers assist patients by lifting dialysate bags, connecting and disconnecting them from the cycler, providing exit site care, and performing basic physical assessments [76].

Assisted PD is associated with favorable clinical outcomes in older patients. Advanced age has consistently been identified as a risk factor for peritonitis, likely because of multiple comorbidities and cognitive or functional impairments [22,23,73]. A retrospective analysis of the French PD registry demonstrated that nurse-assisted PD could reduce the risk of peritonitis in patients aged ≥ 75 years [77]. Another study from the same cohort revealed a significant association between nurse-assisted PD and lower risk of transfer to HD due to inadequate dialysis or infection than self-care PD [78]. Compared with patients who performed self-care PD, those receiving nurse-assisted PD were significantly older, with a median age of 80 years, and had a higher comorbidity index [78]. Therefore, assisted PD is an effective strategy to improve PD accessibility for older patients with functional dependence because it supports the proper manipulation of PD equipment and precise implementation of dialysis regimens prescribed by physicians.

Several strategies could promote the wider adoption of assisted PD in older patients. Stepwise and planned dialysis initiation can help start assisted PD in a timely manner, thereby preventing urgent HD via CVC and the subsequent transition to long-term HD [79]. Early identification of assistance needs and selection of assistance in advance during

Table 3. Typical incremental PD prescription strategies in CAPD and APD

Initial PD prescription	Incrementation	Increased PD prescription
CAPD		
1.5 L × 4 exchanges	Increase dwell volumes	2 L × 4 exchanges ^{a)}
2 L × 2–3 exchanges only during daytime	Increase the number of exchanges and add night dwell	2 L × 4 exchanges ^{a)}
1 × 2 L icodextrin long dwell during night	Add daytime dwell	2 L × 2–3 exchanges during daytime + 2 L icodextrin long dwell during night
4 × 2 L exchanges only on weekdays	Increase frequency	Every day for a week ^{a)}
APD		
3 × 1.5 L cycled over 6 h during night	Increase dwell volumes	2 L × 3 cycled over 6 h during night
3 × 2 L cycled over 6 h during night	Increase number of exchanges	2 L × 4 cycled over 8 h during night
4 × 2 L cycled over 8 h during night	Add daytime dwell	2 L × 4 cycled over 8 h during night + 2 L icodextrin long dwell during daytime ^{a)}
4 × 2 L cycled every other day	Increase frequency	Every day for a week ^{a)}

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; PD, peritoneal dialysis.

^{a)}Full-dose PD.

the initial assessment for PD eligibility can help establish PD as a practical and feasible option for older patients. Furthermore, APD or incremental PD strategies can reduce caregiver burden and barriers to PD entry. After PD initiation, regular assessment of changes in barriers to PD and timely adjustments to assistance are essential to sustain assisted PD. Patients may require additional assistance as their functional capacity declines with age or during acute illness. However, some patients regain independence after initiating dialysis and can transition from assisted to self-care PD. The 2024 ISPD position paper emphasizes that assisted PD should be recognized as a standard modality for patients with functional limitations, especially older patients [27]. The position paper further highlights the importance of implementing adaptable service models tailored to local resources, such as nurse-led or family-supported PD. These recommendations aim to enhance access to PD and reduce reliance on hospital-based HD services. Assisted PD programs, which include funding mechanisms and a stable supply of assistance, are provided by national or regional healthcare systems in many European countries [80,81]. However, in Korea, assistance is largely dependent on family members without financial support or systematic supervision, which may lead to difficulties in maintaining assisted PD. Therefore, establishing financial support through reimbursement policies, structured assisted PD programs, and standardized assistant training at the national level will be the key to expanding assisted PD among

older patients in Korea.

STRATEGIES FOR MANAGING GERIATRIC SYNDROMES IN OLDER PATIENTS

Geriatric syndrome is a multifaceted clinical condition characterized by physical frailty, malnutrition, multiple comorbidities, and cognitive impairment associated with aging. With the growing number of older patients in this population, the prevalence of geriatric syndrome among patients with ESKD is increasing [82]. Most older patients with ESKD have two or more geriatric impairments that are often inter-related [83]. A comprehensive geriatric assessment should be implemented using a multidisciplinary approach involving nutritionists, physiatrists, psychiatrists, and neurologists to improve clinical outcomes in this population [84]. In this section, we discuss the clinical significance of frailty and nutrition, which are the two key components of geriatric syndrome, and propose strategies to improve outcomes in older patients undergoing dialysis.

Frailty

Frailty is a state of reduced ability to recover from physical or medical stress, leading to adverse clinical outcomes [85]. It is more prevalent in patients undergoing dialysis than in the general population [86]. A pre-existing uremic environment

and metabolic disturbances during the pre-dialysis period activate inflammatory pathways and contribute to the development of sarcopenia [87]. Older patients often continue to experience frailty even after initiating dialysis because of nutritional losses during dialysis and frequent hospitalization related to comorbidities [88,89]. Frailty remains an under-recognized but important risk factor for adverse clinical outcomes in this population, including all-cause mortality and hospitalization [90,91].

Frailty assessments include indicators such as unintentional weight loss, self-reported exhaustion, low physical activity, and poor physical performance (Table 4) [90-96]. These assessments should be integrated into every step of the dialysis planning process for older adults. Frailty is a risk factor for death before dialysis initiation and during the course of dialysis in older patients with advanced CKD. Therefore, CKM may be considered a reasonable alternative to dialysis in patients with significant frailty [97]. When older patients decide to initiate dialysis, frailty assessments can help evaluate their physical function and predict the need for additional support. Individualized strategies should be developed to support dialysis based on the type and severity of functional impairment. For example, caregivers may be required to accompany patients who are unable to transfer themselves to HD centers or to support assisted PD in patients with impaired precise handling of PD or cognitive dysfunction. When establishing VA in older patients who opt for HD, frailty increases the risk of AVF maturation failure in addition to factors such as advanced age and comorbidities [98]. In such cases, CVC or AVG may be considered as VA alternatives.

Physical activity interventions can mitigate frailty, improve muscular strength and cardiovascular function, and reduce hospitalization in patients receiving dialysis [99-101]. The 2017 ERBP Clinical Practice Guidelines recommend structured and individualized exercise programs for older patients with advanced CKD, including those undergoing dialysis [10]. Exercise programs tailored to patients' functional capacities and personal preferences can provide feasible and safe exercise training for older patients undergoing dialysis. In particular, intradialytic exercise during HD sessions can potentially enhance safety, improve adherence under the supervision of healthcare professionals, and transform sedentary dialysis time into opportunities for health promotion [99]. Similarly, for patients undergoing PD, the 2022 recommendations of the Global Renal Exercise Network and

ISPD advocate the incorporation of home-based aerobic and resistance exercises, such as walking, cycling, and resistance band training, into daily routines to help prevent frailty and maintain functional independence [102].

Nutrition

Protein-energy wasting (PEW) refers to a form of malnutrition in patients with CKD characterized by an imbalance in protein metabolism, in which catabolism exceeds anabolism, leading to reduced nutritional biomarkers, body mass, and muscle mass [103,104]. The high prevalence of PEW in older patients undergoing dialysis may be attributable to nutritional loss during dialysis, chronic inflammation, inadequate dietary intake associated with aging, and multiple comorbidities [105,106].

Laboratory parameters, dietary records, and body composition measurements can be used to assess the nutritional status of older patients undergoing dialysis [105]. However, changes in body composition in this population present a significant challenge for the accurate assessments of nutritional status. Dilution caused by volume overload can affect nutritional biochemical parameters, such as serum albumin and prealbumin levels. In patients receiving PD, aging and chronic exposure to peritoneal dialysate glucose contribute to an increased proportion of body fat and reduced muscle mass as part of overall body composition. Anthropometric parameters, such as calf circumference, skinfold thickness, and waist circumference, may provide more accurate nutritional assessments than body mass index or total body weight because they better reflect muscle and fat mass. Composite nutritional indices that incorporate both subjective and objective aspects, such as Subjective Global Assessment and Malnutrition Inflammation Scores, can provide a comprehensive approach for evaluating nutritional status [107,108]. Furthermore, body composition analysis using technical devices such as bioelectrical impedance analysis or dual-energy X-ray absorptiometry may support more objective and quantitative assessments of patients undergoing dialysis [107].

Adequate dietary intake is essential for protein synthesis and regarded as a key nutritional intervention. The 2020 KDOQI guidelines for nutrition in CKD recommend 1.0–1.2 g/kg/day of protein and 25–35 kcal/kg/day of energy intake for patients undergoing dialysis, considering increased nutritional loss and catabolism associated with dialysis [107]. When these targets cannot be achieved through dietary

Table 4. Commonly used tool to assess frailty in older adults

Tool	Domain	Classification	Strength	Limitation	Association with clinical outcomes in older patients with ESKD
Fried frailty phenotype	Weight loss, exhaustion, physical activity, weakness, and slowness	Robust: 0 Pre-frail: 1–2 Frail: 3–5	Comprehensive assessment of observed performance and self-reported physical function	Measurements, such as grip strength and walking test, are not easy to execute in routine practice, Lack of co-morbidities and psychosocial components	Mortality [90,92–94] Hospitalization [93,94], Emergency visits [93]
Frailty index	38 frailty components (co-morbidities, disabilities, physical function, and self-reported health, etc.)	Total score of deficits /Total available items: Robust: ≤ 0.08 Pre-frail: $0.09–0.24$ Frail: ≥ 0.25	Multidimensional assessment of frailty, including psychosocial aspects, cognitive function, and co-morbidities	Timing-consuming and complex to implement in routine clinical care	Mortality and Hospitalization [95]
Short physical performance battery	Usual gait speed, repeated standing up from the chair, and standing balance	Worst performance = 0 Best performance = 12 Frailty: ≤ 9	Rapid and objective assessment, Test-retest reliability, clinical applicability	Lack of evaluation of aerobic capacity and psychosocial factor, such as self-efficacy	Mortality and Hospitalization [96]
FRAIL scale	Five items of self-report questionnaire: Fatigue, Resistance, Ambulation, Illness, and Loss of weight	Robust: 0 Pre-frail: 1–2 Frail: ≥ 3	Simple and rapid assessment	Lack of objective assessment	N/A
Clinical frailty scale	Nine descriptors of composite levels of mobility, energy, physical activity, and function	Very fit = 1 Terminally ill = 9 Frail: ≥ 5	Reflection of overall competency in daily life activities, Easy applicability in routine clinical practice	Subjective clinical judgement by the healthcare provider could lead to misclassification	Mortality [97]
Groningen frailty indicator	15 items of self-reported disabilities in four domains (physical, cognitive, social, and psychological)	Frail: ≥ 4	Short questionnaire and good feasibility, Usefulness as a frailty screening tool	Lack of objective assessment	Mortality and Hospitalization [91]

ESKD, end-stage kidney disease; N/A, not available.

intake alone, nutritional supplementation, such as oral, enteral, or intradialytic parenteral nutrition, should be considered [109]. A protein-rich diet contains high phosphate levels, which are associated with increased vascular calcification and mortality risks in patients undergoing dialysis [110]. However, strict phosphorus restrictions can increase the risk of malnutrition, which is particularly detrimental in older patients. Therefore, adequate protein intake combined with phosphate binders can be a practical strategy for maintaining nutritional status while controlling phosphorus levels [111].

Several age-related factors, such as cognitive dysfunction, depression, social deprivation, and functional disorders of the gastrointestinal tract, contribute to suboptimal dietary intake in older patients undergoing dialysis. Psychological and social support should be integrated into a multidisciplinary approach to enhance the effectiveness of dietary interventions. Physicians should perform comprehensive assessments and implement multifaceted strategies to improve the nutritional status of this population.

CONCLUSION

In older patients with advanced CKD, the aging process substantially affects clinical outcomes throughout the trajectory of dialysis from initiation to long-term maintenance. Age-related factors should be carefully considered when determining the timing of dialysis initiation, selecting an appropriate modality, and adjusting dialysis prescriptions. Dialysis management in older patients must evolve toward a more individualized approach, with treatment decisions guided by patient-centered goals, such as quality of life and functional preservation, rather than focusing only on biochemical treatment targets. A multidisciplinary approach and regular reassessments are essential for providing appropriate care to this vulnerable population.

SDM involving nephrologists, other healthcare professionals, patients, and caregivers should be integrated throughout the course of dialysis for older patients with ESKD. In addition, developing clinical guidelines tailored to older adults undergoing dialysis, expanding access to home-based dialysis and conservative care options, and investing in assisted dialysis infrastructure could help provide more effective and individualized care. Future research should establish standardized strategies that incorporate geriatric assessments

to ensure high-quality personalized dialysis in the growing older adult population.

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Supplementary Table 1. Prediction models of mortality and kidney failure in patients with chronic kidney disease G3b–5

Score	Outcome	Variables	Population	Discrimination and calibration
BANSAL [11]	5-yr risk of death without KRT	Age, sex, race, eGFR, ACR, smoking, and comorbidities (diabetes, heart failure, stroke)	Developed in 828 patients who were aged ≥ 65 years and had eGFR < 60 mL/min/1.73 m ² from the Cardiovascular Health Study. Validated in 789 patients from the Health ABC study	0.72/+
KFRE [12]	2- and 5-yr risk of kidney failure	Age, sex, eGFR, ACR (4 variables equation) + calcium, phosphate, bicarbonate, and albumin (8 variables equation)	Initially developed and validated in 8,391 patients with eGFR < 60 mL/min/1.73 m ² from the 2 Canadian provinces, subsequently validated in 721,357 patients from more than 30 countries	0.88–0.91/+
REIN [13]	Overall mortality during the first 3 mo of dialysis	Age, sex, albuminemia, severe behavioral disorder, mobility, and comorbidities (congestive heart failure, peripheral vascular disease, dysrhythmia, cancer)	12,500 patients in training set 11,848 patients in validation set (Both training and validation set were derived from the REIN registry, which include the patients who started dialysis at age > 75 years in the France)	0.76/-

ABC, Aging and Body Composition; ACR, albumin-to-creatinine ratio; eGFR, estimated glomerular filtration rate; KFRE, Kidney Failure Risk Equation; KRT, kidney replacement therapy; REIN, Renal Epidemiology and Information Network.