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REVIEW

Evidence Summary of Personalized Management of Peritoneal Dialysis Volume in Adults

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Purpose: The overload capacity poses great challenges to the management and prognosis of peritoneal dialysis patients. There have been many studies, but they are relatively fragmented and inconsistent. It is urgent to summarize high-quality evidence. The objective of this study is to thoroughly investigate, extract, assess, and synthesize the most relevant evidence about the individualized management of peritoneal volume in patients undergoing peritoneal dialysis. It can be utilized in clinical practice to improve patient outcomes.

Methods: The study used the "6S" pyramid model to identify all available evidence related to the personalized management of peritoneal volume among patients receiving peritoneal dialysis. This comprehensive search encompassed various types of evidence, including guidelines, recommended practices, systematic reviews, evidence summaries, expert consensus documents, and original research studies. These were sourced from both domestic and international guideline websites, professional association platforms, as well as relevant databases. The time limit was set from the date of database creation until April 2024, with the search commencing in December 2023.

Results: The systematic search yielded 17 pieces of literature that were ultimately included in the analysis. This collection comprised seven guidelines, four best practices, two documents reflecting expert consensus, two systematic reviews, and two randomized controlled trials. The overall quality of the literature analyzed was found to be high. Through this thorough review, a total of 37 pieces of the best evidence were identified and categorized into three critical aspects: risk factors, comprehensive assessment methodologies, and various intervention strategies.

Conclusion: This study serves as a consolidation of the available evidence regarding the personalized management of peritoneal volume for patients undergoing peritoneal dialysis. It underscores the importance of clinical staff's ability to implement tailored volume management programs that address the unique circumstances of each patient.

Keywords: individualized management, peritoneal volume, evidence summary, evidence-based nursing

Introduction

Peritoneal dialysis (PD) is a widely utilized kidney replacement therapy for patients with end-stage kidney disease.[1] Both in clinical settings and at home. According to the International Society of Nephrology, the number of individuals receiving chronic PD is 21 per million population and tends to increase with income level globally.[2] The Kidney Disease: Improving Global Outcomes (KDIGO) 2024 Clinical Practice Guideline states that PD should be considered when the glomerular filtration rate (GFR) is less than 15–20 mL/min/1.73 m² or when the risk of requiring renal replacement therapy within two years exceeds 40%.[3] One of the primary objectives of PD is to eliminate solutes and excess fluid to prevent the accumulation of uremic solutes and excessive fluid in the body. However, due to the gradual decline in residual kidney function and excessive intake of water and sodium among PD patients, individuals may experience

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volume overload, manifesting as edema and hypertension. In recent years, the incidence of volume overload in PD patients has become increasingly prevalent.

Some researchers have studied a cohort of 366 patients undergoing peritoneal dialysis for over one year and found that the incidence of fluid excess can be as high as 66%.[4] Studies have demonstrated that excessive volume load in the body can lead to a range of cardiovascular events, including arteriosclerosis and congestive heart failure, as well as an increased readmission rate for patients, which imposes a significant financial burden on their families.[5] Consequently, effective volume management is a crucial component of high-quality peritoneal dialysis.[6] Given the variability in patient height, weight, and overall health status, volume management for PD patients necessitates a personalized approach.

Currently, various design types of evidence have emerged regarding the personalized volume management of PD patients. However, each type of evidence has its distinct focus, resulting in scattered and inconsistent recommendations. One study specifically focused on PDpatients with cardiorenal syndrome but did not address the implementation of personalized volume management strategies.[7] Additionally, several studies have demonstrated the effectiveness of various tools for evaluating volume status, including bioelectrical impedance and remote monitoring technologies.[8,9] Furthermore, different hospitals have adopted varying guidelines, resulting in inconsistencies in aspects such as dialysis volume and abdominal retention time. This variability can easily confuse clinical decision-makers. Therefore, it is essential to summarize the different guidelines for volume management in PD patients, along with other high-quality evidence.

This study employs an evidence-based approach to conduct a comprehensive search for and synthesis of the pertinent evidence regarding personalized volume management specifically for patients undergoing PD. By examining both domestic and international literature, the research seeks to compile and summarize valuable insights that can serve as a practical reference for healthcare professionals in clinical settings. Furthermore, to ensure transparency and rigor in the research process, this study has been officially registered with the Center for Evidence-Based Nursing at Fudan University under the registration number ES20245810.

Methods

There is a lack of reporting standards for evidence summarization; however, the Evidence-based Nursing Center of Fudan University has established reporting standards based on the principles outlined by the Joanna Briggs Institute. These standards encompass six key areas: problem establishment, literature search, literature screening, literature evaluation, evidence summarization and classification, and the formulation of practice recommendations. This study employed the evidence summary reporting standards developed by the Fudan University Evidence-based Nursing Center.[10]

Problem Establishment

The research inquiry was developed utilizing the PIPOST framework.[11] The demographic group (P) consisted of individuals aged 18 years and above who were receiving peritoneal dialysis treatment. The intervention (I) encompassed a variety of strategies directed toward managing volume, which featured restrictions on salt and water intake, analysis of body composition, selection of peritoneal dialysate, care of the catheter, and oversight of fluid consumption during dialysis. The professionals (P) participating in this investigation included physicians, nursing staff, nutritionists, patients, and their relatives. The outcome (O) was oriented toward evaluating the volume status of patients and the success of volume management, gauged through multiple indicators such as OH levels, systolic blood pressure, total body water, extracellular fluid, intracellular fluid, blood pressure, body mass, urine output, ultrafiltration volume, assessment of peritoneal transport characteristics, and serum sodium concentrations. The environment (S) for this study included renal units and facilities dedicated to the follow-up of peritoneal dialysis. The forms of evidence (T) taken into account comprised guidelines, suggested practices, systematic reviews, evidence summaries, consensus from experts, and original research.

Evidence Retrieval

Following the "6S" evidence mode,[12,13] searches were conducted systematically from top to bottom across various sources, such as UpToDate, BMJ Best Practice, and the Cochrane Library. Additional databases and organizations consulted included the JBI Center for Evidence-Based Health Care, the JBI Center for Evidence-Based Nursing, the World Health Organization

(WHO), the Guidelines International Network (GIN), the National Guideline Clearinghouse (NGC), the Registered Nurses' Association of Ontario (RNAO), the New Zealand Guidelines Group (NZGG), the Clinical Practice Guideline Infobase from the Canadian Medical Association (CMA), the Scottish Intercollegiate Guidelines Network (SIGN), the National Institute for Health and Care Excellence (NICE), Web of Science, Embase, Scopus, PubMed, CINAHL, Medlive, SinoMed, CNKI, the Wanfang Database, the VIP Database, the International Society for Peritoneal Dialysis (ISPD), the Campbell Collaboration, the TRIP database, the Chinese Society of Nephrology, the Canadian Society of Nephrology, and the British Society of Nephrology.

A search was performed using a mix of subject-specific terms and general keywords. The search terms included 'peritoneal dialysis/continuous dynamic peritoneal dialysis/automated peritoneal dialysis/ambulatory peritoneal dialysis/tidal peritoneal dialysis/intermittent peritoneal dialysis/dialysis, peritoneal/dialysis, peritoneal/' 'individualized management/capacity management/volume management/liquid management/diet/water/salt/sodium/blood pressure/urine volume/volume/blood volume/fluid status/volume overload/volume insufficiency/residual renal function/dialysate' 'guid*/recommendation*/evidence*/consensus/systematic review/randomized controlled trial/practice'.

The time limit was set from the date of database creation until April 2024, with the search commencing in December 2023. Figure 1 is an example of the PubMed search strategy.

Inclusion and Exclusion Criteria of Evidence

Inclusion Criteria

(1) The search population consisted of peritoneal dialysis patients ≥18 years old; (2) Literature on the assessment, prevention, and intervention of peritoneal volume overload; (3) The outcome indicators involved volume overload and related complications; (4) Literature types included clinical decisions, evidence summaries, guidelines, expert consensus, systematic reviews, and original studies that are closely related to the topic of this study. (5) The languages of research were English and Chinese literature.

Exclusion Criteria

(1) The subjects underwent hemodialysis at the same time and had undergone kidney transplantation; (2) Incomplete literature information or low literature quality, research proposals, conference abstracts; (3) There were updated versions of the old Guide, the Guide interpretation, the Guide translation; (4) The full text cannot be obtained.

Literature Screening

After importing the retrieved literature into EndNote, duplicates were removed. The literature was independently screened by two individuals with expertise in evidence-based nursing research. The initial screening utilized titles,

#1 "Peritoneal Dialysis"[Mesh]

#2 peritoneal dialysis OR continuous dynamic peritoneal dialysis OR automated peritoneal dialysis OR ambulatory peritoneal dialysis OR tidal peritoneal dialysis OR intermittent peritoneal dialysis OR dialyses, peritoneal OR dialysis, peritoneal [Title/Abstract]

#3 #1 OR #2

#4 individualized management OR capacity management OR volume management OR liquid management/diet OR water OR salt OR sodium OR blood pressure OR urine volume OR volume OR blood volume OR fluid status OR volume overload OR volume insufficiency OR residual renal function OR dialysate [Title/Abstract]

#5 guid* OR recommendation* OR evidence* OR evidence summary OR systematic review OR consensus OR randomized controlled trial OR RCT OR practice [Title/Abstract]

#6 #3 AND #4 AND #5

Figure 1 PubMed search strategy.

abstracts, and keywords, followed by a re-screening that involved reading the full texts. Ultimately, the final selection of literature underwent a careful evaluation process to assess its quality, thereby guaranteeing the integrity and reliability of the information that would be utilized in the research.

Quality Evaluation of the Literature

The guidelines' quality was assessed through the use of the Appraisal of Guidelines for Research and Evaluation II (AGREE II).[14,15] This assessment instrument includes six dimensions and twenty-three distinct items, in addition to two overall evaluation items. Each item received a rating on a scale from 1 to 7 (where 1 indicates strong disagreement and 7 indicates strong agreement). The standardized percentage for each domain is derived using the formula: (actual score - minimum possible score) / (maximum possible score - minimum possible score) × 100%. Quality ratings are categorized as follows: if all six domains achieve scores of 60% or higher, they are assigned a Grade A (highly recommended); if three or more domains score below 60% but at least 30%, they receive a Grade B (recommended); and if three or more domains score below 30%, they are given a Grade C (not recommended).

The systematic review was evaluated utilizing the systematic review tool created by the Australian JBI Centre for Evidence-Based Health Care.[16] This evaluation tool contains 11 items, each with four response alternatives: "Yes", "No", "Unclear", and "Not Applicable". Randomized controlled trials were evaluated using the Randomized Controlled Trial Evaluation Tool from the JBI Centre for Evidence-Based Health Care in Australia. This tool includes 13 evaluation items, each providing four response choices: "Yes", "No", "Unclear", and "Not Applicable".[17]

The assessment of expert consensus was conducted using the Expert Consensus Evaluation Tool developed by the JBI Centre for Evidence-Based Health Care located in Australia. This tool comprises six evaluation items, each providing identical four response options: "Yes", "No", "Unclear", and "Not Applicable".[18] While the evidence level and quality within the clinical decision and evidence summary are remarkably high, there is presently no standardized method for assessing the quality of these summaries and clinical decisions.[19] Consequently, the evaluation of the quality of literature depends on the original evidence sources, choosing suitable evaluation criteria according to the type of literature.

Evidence Extraction and Summary

Two members of a research team, both with expertise in evidence-based medicine, consolidated the evidence based on the following guidelines: (1) if the information was consistent, evidence was chosen to represent concentrated expertise; (2) when various sources of evidence were either similar or complementary, they were combined into a unified piece of evidence; and (3) in cases where evidence from several sources differed, the highest quality or most recently published evidence from authoritative, evidence-based journals was utilized. The JBI evidence pre-classification and evidence recommendation level system (2014 version) categorizes the level of evidence into five tiers, ranging from high to low.[20]

Result

Search results

1,431 literature sources were obtained in the preliminary search, with 17 included in Endnote 20 after the removal of duplicates and a quality evaluation.[21–37] This selection comprised 4 best practices,[21–24] 7 guidelines,[25–31] 2 expert consensus documents,[32,33] 2 systematic reviews,[34,35] and 2 randomized controlled trials.[36,37] The literature search and screening process is illustrated in Figure 2, while the general characteristics of the included literature are presented in Table 1.

Literature Quality Evaluation Results

Quality Evaluation Results of Guidelines

Seven guidelines were included in this study.[25–31] The scores of the four guidelines in each field were ≥ 60%, and the recommendation level was A level,[27,29–31] while the other guidelines were level B.[25,26,28] The results of the methodological quality assessment of the guidelines are shown in Table 2.

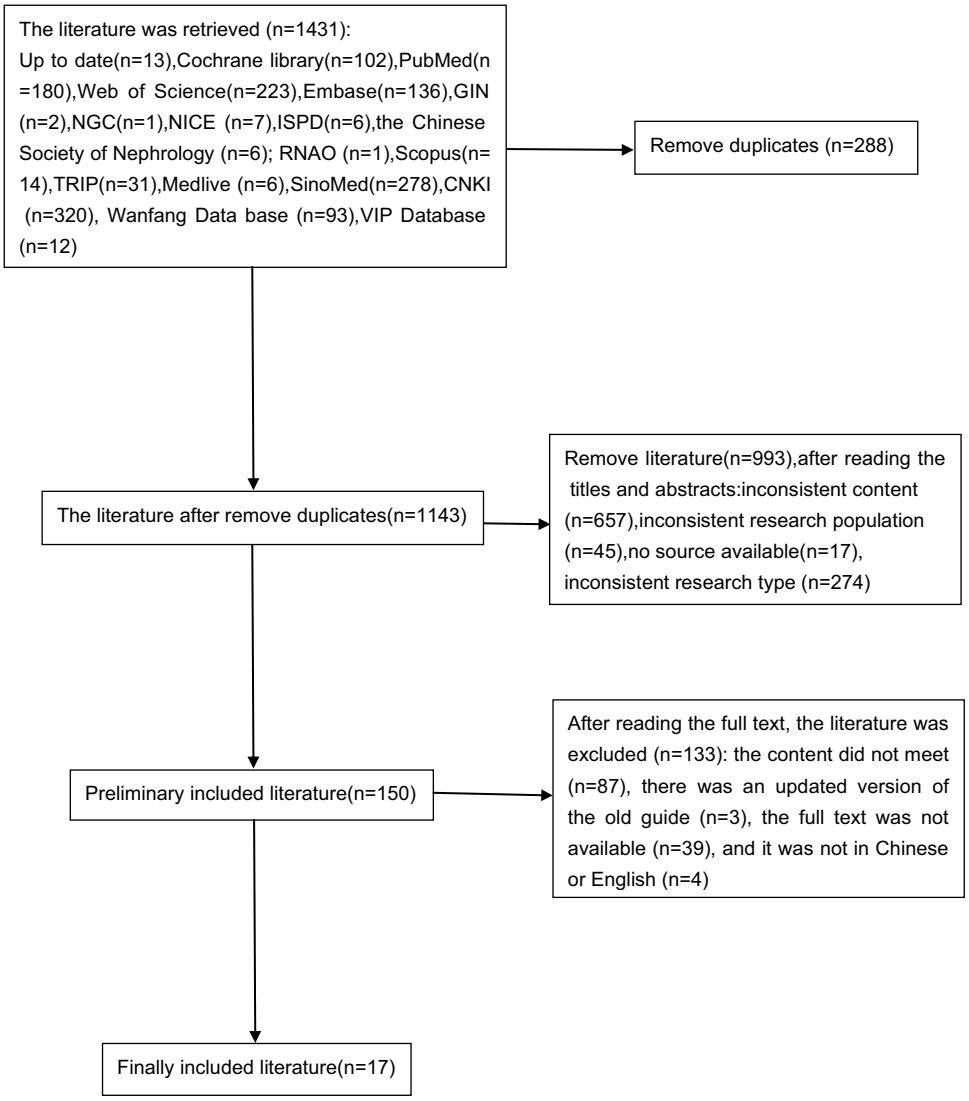

Figure 2 Literature screening flow chart.

Quality Evaluation Results of Expert Consensus and Best Practice

In the two expert consensus papers[32,33] and four best practices,[21–24] Ji Jun et al[30] received a "No" evaluation for item 4 and item 6, while the remaining items were rated "Yes". The Chinese Medical Doctor Association Branch of Nephrology Physicians[32] was rated "No" for item 6, with the other items receiving a "Yes" evaluation. All items in the four best practices[21–24] were rated "Yes". Overall, the quality of the literature is high, and it was included in the study.

Quality Evaluation Results of Systematic Reviews

This study encompassed two systematic reviews.[34,35] Beaubien-Souligny et al[34] received an "Unclear" rating for item 10, while all other items were rated as "Yes". Similarly, Goossen et al[35] were rated as "Unclear" for item 3, with all remaining items receiving a "Yes" rating.

Quality Evaluation Result of the Randomized Controlled Trials

Two randomized controlled studies were included in this study. Brimble et al[36] received an evaluation of "Unclear" for item 8, while all other items were rated "Yes". Similarly, Oh, K. H. et al[37] were assessed as "Unclear" for items 2 and 6, with the remaining items rated "Yes".

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Table 1 Basic Characteristics of Included Studies

	Source	Year of Publication	Type of Literature	The Literature Theme
JohnM Burkart et al[21]	UpToDate	2023	Best practice	Nutritional status and protein intake in peritoneal dialysis patients
JohnM Burkart et al[22]	UpToDate	2023	Best practice	Management of hypervolemia in peritoneal dialysis patients
Muhammad Alam et al[23]	UpToDate	2024	Best practice	Introduction and application of peritoneal dialysis fluid
Rajiv Agarwal et al[24]	UpToDate	2024	Best practice	Hypertension management in peritoneal dialysis patients
Chinese Medical Renal Physicians Branch[25]	Medlive	2021	Guideline	China Clinical Practice Guidelines for Nutritional Treatment of Chronic Kidney Disease
China peritoneal dialysis catheterization expert Group[26]	Medlive	2016	Guideline	Chinese peritoneal dialysis catheterization guidelines
Society of Nephrology, Chinese Medical Association[27]	Medlive	2022	Guideline	Guidelines for the management of chronic heart failure in Chinese dialysis patients
Expert Group of Chinese Society of Nephrology[28]	Medlive	2022	Guideline	Chinese guidelines for renal replacement therapy for end-stage diabetic kidney disease
British National Institute for Health and Care Excellence[29]	NICE	2018	Guideline	Renal replacement therapy and conservative management
British National Institute for Health and Care Excellence[30]	NICE	2017	Guideline	Multiple frequency bioimpedance devices to guide fluid management in people with chronic kidney disease having dialysis
British National Institute for Health and Care Excellence[31]	NICE	2018	Guideline	Clinical practice guidelines for peritoneal dialysis in adults and children
Chinese Medical Doctor association nephrologist Branch[32]	Medlive	2021	Expert consensus	Chinese expert consensus on automated peritoneal dialysis
Ji et al[33]	Medlive	2018	Expert consensus	Expert consensus on peritoneal dialysis technology and management in primary hospitals
Beaubien-Souligny et al[34]	Cochrane Library	2019	Systematic review	Meta-analysis of randomized controlled trials using tool-assisted target weight adjustments in chronic dialysis patients
Goossen et al[35]	Web Of Science	2020	Systematic review	Icodextrin versus glucose solutions for the once-daily long dwell in peritoneal dialysis: an enriched systematic review and meta-analysis of randomized controlled trials
Brimble et al[36]	Cochrane Library	2022	Randomized controlled trial	Impact of bioelectrical impedance–guided fluid management and vitamin D supplementation on left ventricular mass in patients receiving peritoneal dialysis: a randomized controlled trial
Oh et al[37]	Cochrane Library	2018	Randomized controlled trial	Effectiveness of routine bioimpedance-guided fluid management in peritoneal dialysis patients: COMPASS clinical trial

Abbreviation: NICE, the National Institute for Health and Care Excellence.

Summary and Description of Evidence

A total of 37 pieces of evidence were extracted from 17 literatures included and integrated into three aspects: risk factors, comprehensive assessment, and intervention strategies, as shown in Table 3.

Table 2 Quality Evaluation of Included Guidelines

Guideline	Percentage of Field Standardisation (%)						≥60%	≥30%	Quality Grade
	Scope and Purpose	Stakeholder Involvement	Rigour	Clarity	Applicability	Independence			
Chinese Medical Doctor Association renal Physicians Branch[25]	91.67	69.44	66.67	83.33	45.83	66.67	5	6	B
China peritoneal dialysis catheterization expert Group[26]	83.33	61.11	40.63	88.89	37.50	50.00	3	6	B
Society of Nephrology, Chinese Medical association[27]	91.67	77.78	63.54	88.89	85.42	75.00	6	6	A
Expert Group of Chinese Society of Ne-phrology[28]	97.22	72.22	41.67	80.56	68.75	75.00	5	6	B
NICE[29]	94.44	94.44	75.00	91.67	81.3	87.50	6	6	A
NICE[30]	91.67	83.33	78.13	91.67	85.42	83.33	6	6	A
Woodrow G et al[31]	94.44	91.67	88.54	94.44	87.50	85.50	6	6	A

Abbreviation: NICE, the National Institute for Health and Care Excellence.

Table 3 Evidence Summary of Personalized Management of Peritoneal Volume in Peritoneal Dialysis Patients

Aspects	Description of Evidence	Evidence Level
Risk factor	1. Risk factors for volume overload in peritoneal dialysis patients include the loss of residual renal function, excessive intake of water and sodium, poor compliance, and a mismatch between the dialysis prescription and the peritoneal transport type. Additional factors encompass hypoalbuminemia, hyperglycemia, the accumulation of dialysate due to mechanical issues such as catheter misplacement, multiple adhesions, or retroperitoneal fluid leakage, as well as ultrafiltration failure.[29]	5b
Comprehensive assessment	2. It is recommended to closely and dynamically evaluate patients' clinical manifestations, including blood pressure, body weight, and edema. Bioelectrical impedance technology offers advantages such as high accuracy, good repeatability, safety, and non-invasiveness. When feasible, this technology can be employed to assist in determining fluid volume, while also comprehensively considering urine output and ultrafiltration volume to evaluate water clearance.[24,25]	1a
	3. The application of bioimpedance analysis and vitamin D supplementation demonstrated potentially beneficial effects on fluid overload and enhanced vitamin D levels; however, no significant impact was observed on left ventricular mass.[36]	1c
	4.It is recommended that peritoneal equilibration test (PET) or the equivalent method be used to regularly monitor peritoneal function (at least 6 weeks after the start of treatment, at least annually or when clinical indications occur). Daily urine volume and peritoneal ultrafiltration volume should be monitored for at least 6 months, and overcharge should be appropriately corrected.[27]	1c
	5. For patients with a urine volume exceeding 100 mL/d, residual renal function should be assessed every 3 to 6 months.[24]	1a
	6.2.5% or 4.25% glucose PET should be conducted no sooner than 4 weeks after initiating peritoneal dialysis.[27]	1c
	7. It is advisable to collect blood, urine, and dialysate samples to evaluate electrolytes, high-resolution C-reactive protein, total cholesterol, triglycerides, dialysis adequacy, peritoneal transport characteristics, and residual renal function.[37]	1c
	8. Abdominal X-rays can be performed to verify optimal catheter positioning; additionally, abdominal and pelvic MRI scans or CT scans with intraperitoneal contrast agent injection can identify catheter leakage. Catheter flow examinations (catheter imaging) can help determine if drainage failure is due to a retinal wrap.[29]	5b
Intervention strategy	9. Validation of the accuracy of multi-frequency bioimpedance devices is necessary for patients with amputations who cannot be measured using the recommended electrode configuration and positioning.[26]	1a
	10. Close monitoring of patients with anuria who have excess water retention, along with daily ultrafiltration of less than 750 mL for adults, is recommended.[37]	1c
	11. It is advisable to avoid dialysis regimens that lead to fluid reabsorption, and patients with high or elevated mean solute transport should consider using automated peritoneal dialysis (APD) and icodextrin as an abdominal dialysis solution.[27,37]	1a

(*Continued*)

Table 3 (Continued).

Aspects	Description of Evidence	Evidence Level
Food and beverage management	12. Dialysis regimens that routinely utilize hypertonic (3.86%) glucose exchanges should be minimized, and dextrin acetate or diuretics should be employed as appropriate.[27]	1c
	13. For patients with residual renal function, fluid intake is not restricted at the onset of peritoneal dialysis; however, as residual renal function declines, many patients may need to limit their fluid intake.[24,29]	5b
	14. Protein intake: The recommended protein intake (DPI) for patients with no residual renal function is 1.0 to 1.2 $g \cdot kg^{-1} \cdot d^{-1}$, whereas for patients with residual renal function, it is 0.8 to 1.0 $g \cdot kg^{-1} \cdot d^{-1}$.[21,24] If a patient develops elevated levels of potassium, phosphate, or urea nitrogen, the initially recommended protein intake may be reduced during follow-up.[28]	2d
Food and beverage management	15. Sodium intake: It is advisable to limit sodium intake to less than 2 g/d (with sodium chloride intake not exceeding 5 g/d) or to follow an unsalted diet, unless the patient has no residual kidney function, in which case fluid intake will not be restricted.[25]	2d
	16. Energy intake: The recommended caloric intake is 35 kcal $g \cdot kg^{-1} \cdot d^{-1}$ (1 kcal = 4.184 kJ). This recommendation may be adjusted to 30 to 35 kcal $g \cdot kg^{-1} \cdot d^{-1}$ for patients over 60 years of age who exhibit low activity levels and maintain good nutritional status.[21,24]	2d
	17. The recommended daily fluid intake for peritoneal dialysis patients with stable volume is calculated as 500 mL plus the urine volume from the previous day, in addition to the net removal of peritoneal dialysis fluid from the prior day.[21,23]	2d
Daily monitoring	18. Home self-testing is employed to monitor blood pressure, with the recommended frequency being twice a day for a minimum of three days. It is advised to conduct home blood pressure monitoring at least once a month.[31]	5b
	19. The guideline suggests maintaining self-measured blood pressure below 130/80 mmHg during dialysis intervals.[29]	5b
Daily monitoring	20. Patients are instructed to wear only close-fitting clothing when weighing themselves daily, to weigh themselves immediately after changing a bag of dialysate, and to record their weight after deducting the weight of the dialysate.[23]	1c
	21. If hypotension occurs, ultrafiltration should be restricted. For patients with severe hypertension, it is recommended to reduce the dry weight at a rate of 0.5 to 1.0 kg per week.[22,27]	5b
	22. For patients undergoing Continuous Ambulatory Peritoneal Dialysis (CAPD), it is recommended to utilize a peritoneal dialysis machine and to divide the long-term overnight abdominal retention into two sessions. For patients on Automated Peritoneal Dialysis (APD) with daytime abdominal retention, it is advisable to either change the fluid at noon or refrain from further injecting dialysis fluid after drainage at noon, ensuring that the abdomen remains dry for a designated period.[22,24]	2d
	23. It is recommended to alternate solutions containing glucose at varying concentrations to effectively control both dry weight and blood pressure[23]	5b
Pharmaceutical administration	24. Treatment strategies that promote the preservation of renal function or volume, including the use of ACE inhibitors (ACEI) or angiotensin receptor blockers (ARB) and diuretics, as well as the avoidance of dehydration episodes, are recommended whenever feasible.[23,27]	1a
	25. For PD patients who have a urine volume exceeding 100 mL per day, high doses of oral Furosemide (250 mg daily) and oral methazolone (5 mg daily) may be considered, provided there are no indications of postural hypotension or volume depletion.[27]	1b
	26. In patients with urine volumes greater than 100 mL per day, loop diuretics can be employed to enhance urine output.[23,32]	5b
	27.The use of nephrotoxic agents, such as iodine contrast media, should be avoided, as well as the long-term (exceeding 3 weeks) administration of aminoglycoside antibiotics and other nephrotoxic drugs.[24]	1a
The selection of peritoneal dialysate	28. For optimal preservation of residual kidney function, long-term (>12 months) use of biocompatible peritoneal dialysis solutions, characterized by normal pH and/or low concentrations of glucose degradation products, is recommended.[25,32]	1a
	29. To improve the appetite of patients undergoing peritoneal dialysis, the regular dialysate containing glucose can be substituted with a dialysate containing amino acids once daily.[28]	5b

(*Continued*)

Table 3 (Continued).

Aspects	Description of Evidence	Evidence Level
The selection of peritoneal dialysate	30. Icodextrin dialysate has been shown to enhance ultrafiltration, particularly during prolonged abdominal retention in patients exhibiting rapid peritoneal transport. This substance is relatively inert and is absorbed slowly, thereby maintaining an osmotic gradient and facilitating continuous ultrafiltration.[23,24,29,32]	1a
	31. In diabetic patients, insulin is frequently added to peritoneal dialysate to aid in controlling hyperglycemia and to mitigate the glucose load resulting from glucose-containing solutions.[30]	5b
Catheter care	32. It is crucial to ensure that the patient's stool remains unobstructed, to avoid bending the knee and squatting on the bed, and to securely fix the catheter to prevent displacement.[22,33]	1a
	33. In the event of catheter displacement, appropriate laxatives may be administered to promote intestinal peristalsis, along with abdominal massage and suitable activities to encourage catheter repositioning.[32]	5b
Catheter care	34. Should an obstruction occur during the extraction of abdominal permeation fluid, 50 to 60 mL of normal saline can be quickly infused into the catheter under pressure, and heparin saline or urokinase may be utilized to clear the catheter.[32]	5b
Automate peritoneal dialysis	35. It is recommended to exchange APD 3 to 5 times during the night.[32]	5b
	36. Furthermore, the dialysis adequacy target for patients undergoing continuous ambulatory peritoneal dialysis and automated peritoneal dialysis should be a weekly total Kt/V of at least 1.7.[24,32] For patients with anuria, the weekly peritoneal Kt/V should also be no less than 1.7.[24]	1a
	37. APD patients in stable condition should have follow-up appointments in the outpatient department at least once every three months, and the frequency of telephone and remote internet follow-ups should occur at least once a week.[32]	5b

Discussion

Identifying the Risk Factors of Capacity Overload as the Foundation of Capacity Management

Currently, patients undergoing peritoneal dialysis often experience insufficient dialysis. Research indicates[38] that 72.1% of dialysis patients have excess fluid levels of ≥1L, while 20.5% have excess fluid levels of ≥5L. This fluid overload can lead to increased cardiac output and systemic vascular resistance, ultimately resulting in elevated blood pressure, arteriosclerosis, and congestive heart failure. Therefore, it is crucial to enhance the management of capacity status in PD patients, as well as to implement effective prevention and strategies for capacity overload. This approach aims to improve patients' quality of life and alleviate their economic burden. The first piece of evidence identifies common clinical risk factors associated with volume overload in PD patients. Although the specific risk factors may vary among individuals, excessive intake of water and sodium, along with poor adherence to treatment protocols, are prevalent risk factors for most PD patients. Consequently, we can strategically manage patients' water and sodium intake while simultaneously enhancing their compliance from a nursing perspective. For instance, Evidence 16 suggests that PD patients should limit their sodium intake to less than 2g per day or adhere to a salt-free diet. Additionally, for patients without residual kidney function, fluid intake should be restricted to approximately 2L per day.[27]

Renal insufficiency refers to a condition in which kidney function is partially or completely impaired, preventing the kidneys from performing their physiological functions effectively. Due to the compromised renal excretion and regulatory functions, patients with renal insufficiency often experience volume overload, electrolyte imbalances, and toxin accumulation. Peritoneal dialysis, as an alternative therapy, can effectively eliminate metabolic waste and excess fluid by adjusting the volume of dialysate used. As the renal function of patients undergoing peritoneal dialysis continues to decline, the residual renal function plays a crucial role in determining the appropriate volume of dialysate. Patients with a higher residual urine volume may reduce the dialysate volume (eg, 1.5–2.0 L per session) to compensate for the insufficient removal of solutes.[39,40]

During the COVID-19 pandemic, many PD centers were closed or faced flow restrictions, leading to peritoneal dialysis becoming the preferred treatment option. One study suggested increasing the frequency of hypertonic dialysis fluid usage. Patients undergoing automated peritoneal dialysis either prolonged the dwell time or increased the number of nighttime cycles.[41] Nephrologists monitored ultrafiltration volume, blood pressure, and symptoms in real-time through

mobile applications or cloud platforms. However, unlike hemodialysis, peritoneal dialysis necessitates advance preparation of dialysis fluid. Any logistical interruptions during this period could result in an insufficient supply of dialysis fluid. Consequently, some studies recommended reducing the amount of single dialysis fluid or extending the dwell time to optimize the utilization of existing dialysis fluid.[42,43] Telemedicine has rapidly expanded out of necessity. It is undeniable that the application of telemedicine technology allows for more flexible and individualized adjustments to dialysis fluid volume. Through remote monitoring, the dialysis fluid volume can be adjusted in real time, particularly for patients experiencing fluctuations in blood pressure or changes in volume status.

Medical Staff Should Enhance the Comprehensive Assessment of the Capacity Status of Peritoneal Dialysis Patients

Evidence 2 to 10 highlights the critical aspects of evaluating volumetric status in PD patients and summarizes common screening methods. In assessing volume status, it is advisable to closely and dynamically monitor clinical manifestations such as blood pressure, body weight, and edema. Additionally, bioelectrical impedance technology offers advantages including high accuracy, good repeatability, safety, and a non-invasive approach. When feasible, the application of bioelectrical impedance technology can aid in volume assessment, taking into account urine output and ultrafiltration volume to evaluate water clearance. However, there remains some debate regarding the validity of estimating capacity states. One study indicates[37] that in non-anuric PD patients, conventional bioimpedance spectroscopy may not provide significant benefits in volume control or the preservation of residual renal function. Therefore, further high-quality studies are necessary to explore the efficacy of bioelectrical impedance technology.

The International Society for PD recommend that for hypertensive patients experiencing volume overload, the proportion of high-permeability dialysis fluid should be increased, or the parameters of automated peritoneal dialysis should be adjusted. Automated peritoneal dialysis can more effectively manage the volume load in patients with fluctuating blood pressure by allowing for flexible adjustments in the amount of dialysis fluid used at night (eg, 2.5–3.0 L per session) and the duration of abdominal retention.[44] However, in patients with stable blood pressure, excessive ultrafiltration may pose a risk of hypotension. Therefore, it is essential to strike a balance between solute clearance and volume management objectives. Future research should further investigate the blood pressure control status of hypertensive patients in a stratified manner to develop individualized dialysis plans.

Interestingly, a recent study derived the mathematical formula: $V_D = (1.2 \times \text{std- Kt/ V} \times \text{TBW})/(t_{dwell} + 4)$ to estimate the dialysate volume required to achieve the PD target dose. This equation serves as a practical tool for estimating the solute gap and guiding continuous PD prescriptions.[45]

Health Care Workers Should Develop Health Guidance Programs Tailored for Personalized Volume Management in Peritoneal Dialysis Patients

Personalized management is an approach that considers individual differences and addresses the specific needs of each patient through customized strategies and methods, thereby enhancing the relevance and effectiveness of care. Regulating sodium intake can down-regulate the activity of the renin-angiotensin-aldosterone system, effectively lowering blood pressure, reducing urinary protein, and alleviating volume overload. Consequently, dietary management emerges as a crucial non-pharmacological intervention for volume control. Evidence from studies 14–21 underscores the significance of dietary management and regular monitoring in maintaining volume balance. However, as residual renal function varies among PD patients, their dietary and fluid intake should adhere to personalized guidance and recommendations provided by dietitians and clinical healthcare professionals. Additionally, daily monitoring of blood pressure and weight constitutes another essential measure. A large cross-sectional study involving 1425 PD patients[46] revealed a higher prevalence of concealed hypertension within the PD population compared to the general population. This finding indicates that healthcare professionals should prioritize monitoring the blood pressure levels of patients with high BMI, and those with diabetes.

Evidence 26–30 provides a summary of the selection criteria for peritoneal dialysis solutions for patients undergoing peritoneal dialysis. Notably, evidence 28, derived from the 2018 edition of the NICE guidelines,[31] recommends that

patients with high or elevated mean solute transport consider using icodextrin peritoneal dialysis solution (1A). Currently, the predominant long-term peritoneal dialysate utilized in China is the traditional glucose-based solution, which employs glucose as an osmotic agent to facilitate dialysis through osmotic pressure. However, the clinical use of glucose-based dialysate presents certain limitations, as relatively high concentrations of glucose can lead to hyperglycemia and insulin resistance. In contrast, icodextrin peritoneal dialysate, which received market approval in China in 2021, is devoid of glucose. This characteristic allows it to reduce patients' exposure to peritoneal glucose, making it a more suitable option for PD patients with suboptimal blood glucose control. Furthermore, Na Yifan et al[47] reviewed six systematic studies and one economic analysis concerning icodextrin peritoneal dialysate, concluding that it outperforms glucose peritoneal dialysate in enhancing ultrafiltration volume among patients. Despite these advantages, icodextrin peritoneal dialysate has not yet gained widespread adoption in China. Therefore, further real-world studies are anticipated to yield more comprehensive evidence to support its clinical application.[48]

Evidence 31–33 delineates the primary considerations for catheter management in patients under PD patients. In recent years, numerous researchers have developed risk prediction models to identify high-risk factors for peritonitis in PD patients, as well as risk assessment scales for clinical use.[49–51] However, the implementation of these risk assessments has been limited due to the demands of clinical nursing workloads. It is recommended that nursing staff create simplified and user-friendly evaluation scales tailored to the specific characteristics of peritonitis patients within their departments. Furthermore, integrating these scales with electronic systems could enhance their clinical application and facilitate broader adoption.

Conclusion

This study summarizes the most compelling evidence regarding volume assessment and management for PD patients. It offers evidence-based guidance for healthcare professionals to develop personalized volume management plans, addressing various aspects such as daily life, dietary recommendations, medication management, dialysis solution selection, and catheter care. Differences in ethnicity, region, and cultural background may influence the study's results. Additionally, this study includes only works published in English and Chinese, thereby excluding those published in other languages. Furthermore, disparities in the environments of different hospitals may affect the implementation of the evidence and present various challenges. Therefore, it is crucial to consider the specific circumstances of the hospital department and to take into account the interests and preferences of patients. Future research directions could focus on methodologies for evidence-based transformation research, integrating departmental characteristics and the specific conditions of patients to facilitate the application of this evidence.

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Disclosure

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