Rehabilitation Service Standards for Elderly Patients with Multimorbidity Complicated by Acute Kidney Injury: Post-print

Authors: Wang Tingting, Lin Zehua, Ma Yingchun, Kidney Disease Rehabilitation Professional Committee, Chinese Association of Rehabilitation Medicine, Ma Yingchun

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Abstract

Acute kidney injury superimposed on multimorbidity in elderly individuals (also known as "geriatric multimorbidity") is highly prevalent in clinical practice. Early and timely rehabilitation intervention can improve patients' quality of life and clinical outcomes. This guideline aims to provide recommendations for clinical and rehabilitation therapy specialists regarding the implementation of rehabilitation for patients with geriatric multimorbidity complicated by acute kidney injury.

Full Text

Preamble

Standard · Guideline · Specification: Specification of Rehabilitation Service for Elderly Patients with Comorbidity Complicated with Acute Kidney Injury

Wang Tingting, Lin Zehua, Ma Yingchun*, Committee of Kidney Disease Rehabilitation, Chinese Association of Rehabilitation Medicine

Affiliation: Kidney Disease Rehabilitation Center, Beijing Boai Hospital, China Rehabilitation Research Center/Rehabilitation Medical College, Capital Medical University, Beijing 100068, China

*Corresponding author: Ma Yingchun, Chief Physician; Email: mych323@163.com

Abstract Acute kidney injury (AKI) superimposed on multimorbidity (also known as "geriatric comorbidity") in elderly individuals is highly prevalent in clinical practice. Early and timely rehabilitation intervention can improve

patients' quality of life and clinical outcomes. This guideline aims to provide guidance for clinical and rehabilitation professionals in implementing rehabilitation services for elderly patients with comorbidity complicated by AKI.

[**Key words**] Comorbidities; Acute kidney injury; Rehabilitation services; Standards; Group standards

According to data from the National Bureau of Statistics, by the end of 2023, China' s population aged $ $60 years reached 296 million, accounting for 21.1% of the total population, while those aged $ $65 years totaled 216 million (15.4% of the population). These numbers are projected to increase to 430 million and 320 million, respectively, by 2050 [1-2]. Reports indicate that the prevalence of multimorbidity among elderly populations across different regions in China ranges from 47.5% to 75% [3-4], with these patients being clinically susceptible to acute kidney injury (AKI) [5]. Some patients progress to chronic kidney disease and even require renal replacement therapy. Elderly patients with comorbidity complicated by AKI (AKI-GC) experience multiple functional impairments [6], and early, timely rehabilitation intervention can improve their quality of life and clinical prognosis [7]. As China' s elderly population continues to grow, the demand for rehabilitation services among AKI-GC patients has surged, necessitating the development of standardized rehabilitation service specifications to guide clinical and rehabilitation practitioners in better managing these patients.

This specification establishes standard terminology, definitions, basic requirements, assessment methods, and rehabilitation implementation protocols for AKI-GC patients. It applies to clinical physicians, rehabilitation therapists, nursing staff, and related multidisciplinary teams at all levels of medical institutions (including general hospitals, rehabilitation specialty hospitals, and geriatric hospitals) to guide both inpatient and post-discharge rehabilitation services.

This specification applies to patients aged $ $60 years who meet the criteria for geriatric comorbidity and AKI, covering rehabilitation interventions during the critical ICU phase, general ward hospitalization, and post-discharge recovery period.

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2 Normative References

The following documents contain provisions that constitute essential requirements of this specification:

- *General Safety Requirements for Rehabilitation Training Devices* (GB 24436)
- *Assessment Standards for Older Adult Capacity* (GB/T 42195-2022)
- KDIGO 2012 Clinical Practice Guideline for Acute Kidney Injury

3 Terms and Definitions

The following terms and definitions apply to this document.

3.1 Geriatric Comorbidity

Geriatric comorbidity refers to the simultaneous presence of two or more health problems (including organ diseases, mental health issues, and other conditions affecting elderly individuals) in the same older adult that persist for one year or more [8-9].

3.2 AKI

AKI is a clinical syndrome characterized by rapid deterioration of kidney function within a short period, manifested by decreased glomerular filtration rate (GFR), retention of nitrogenous waste products such as creatinine and urea nitrogen, water-electrolyte and acid-base imbalances, and potentially multi-system complications in severe cases. According to the 2012 KDIGO Clinical Practice Guideline [10], AKI is diagnosed when any of the following criteria are met: (1) serum creatinine increases by $ $0.3 mg/dL (26.5 mol/L) within 48 hours; (2) serum creatinine increases to $ 1.5–1.9$times baseline within 7 days; or (3) urine output decreases to $< 0.5 mL \cdot kg^{\{-1\}\cdot h}\{-1\}$ for $ $6 hours. The renal function staging criteria for AKI-GC patients are shown in Table 1 .

4 Basic Requirements

4.1 Team Requirements

4.1.1 Multidisciplinary Team (MDT) Rehabilitation services for AKI-GC patients should be provided by a multidisciplinary team (MDT) [11] comprising nephrologists, geriatricians, cardiologists, orthopedists, nutrition specialists, psychiatrists, rehabilitation therapists, pharmacists, and specialized nurses. The team should establish an integrated multidisciplinary platform encompassing clinical care, patient education, health counseling, dietary management, exercise training, psychological intervention, and rehabilitation nursing to maximize collaborative effectiveness and achieve comprehensive intervention.

4.1.2 Personnel Qualifications All team members must possess relevant professional degrees, nationally recognized professional credentials, and have completed at least six months of specialized training in rehabilitation knowledge. For centers lacking rehabilitation physicians or therapists, nephrology physicians and/or nursing staff should participate in rehabilitation-related training and obtain relevant qualifications.

4.1.3 Staffing Configuration For institutions that have initiated rehabilitation prevention services for AKI-GC patients but face challenges in recruiting qualified professionals in the short term, collaboration with qualified rehabilitation institutions is recommended. The ratio of rehabilitation intervention staff to patients should be no less than 1:4.

4.2 Equipment Requirements

4.2.1 Functional Assessment Tools **Basic equipment:** Height and weight scale, measuring tape, stopwatch, dynamometer, sphygmomanometer, pulse oximeter, activities of daily living assessment scales, quality of life assessment scales, and psychological function assessment scales.

Standard equipment: Geriatric rehabilitation evaluation and training system, cardiopulmonary exercise testing system, muscle strength assessment and training system, multi-joint isokinetic training and evaluation system, body composition analyzer, and dynamic/static balance evaluation system.

4.2.2 Exercise Rehabilitation Equipment **Basic equipment:** Training mats or yoga mats, foot pedals, dumbbells, sandbags, resistance bands, balance balls, cycle ergometers, treadmills, supine rehabilitation cycle ergometers, and pedometers or activity trackers.

Standard equipment: In-hospital exercise software management system, telemetry ECG monitoring system, rehabilitation training equipment (electric rehabilitation beds, limb linkage training devices, upper and lower limb active/passive training devices, core muscle group strength training equipment, balance function training equipment, and comprehensive hand function training equipment for occupational therapy), and psychological-cognitive rehabilitation training systems. All rehabilitation training equipment must comply with GB 24436 requirements.

4.2.3 Emergency Equipment **Basic equipment:** Cardiac defibrillator, emergency cart with conventional medications (including epinephrine, nitroglycerin, dopamine, atropine, etc.), oxygen supply facilities, sphygmomanometer, and ECG machine.

Standard equipment: Cardiac monitor.

5 Assessment and Rehabilitation Implementation

5.1 Assessment Methods

5.1.1 General Principles Pre-rehabilitation assessment is a critical component for developing exercise prescriptions and evaluating rehabilitation efficacy. Assessment should be conducted throughout the entire treatment process for AKI-GC patients through a continuous cycle of assessment → rehabilitation → re-assessment → plan adjustment → further rehabilitation to continuously improve rehabilitation quality.

5.1.2 Clinical Indicator Assessment **5.1.2.1 Medical History:** Including systemic symptoms (fever, cough, chest tightness, chest pain, abdominal discomfort, dizziness, headache, urinary frequency, urgency, dysuria, back pain, etc.); 24-hour fluid intake and output records; past medical history (cardiovascular and cerebrovascular diseases, pulmonary diseases, hypertension, diabetes, malignancies, orthopedic abnormalities, diabetic foot); medication history and drug allergies; previous surgical history; lifestyle and exercise habits; and family history.

5.1.2.2 Physical Examination: Including height, weight, waist circumference, blood pressure, heart rate, chest and abdominal examination findings, lumbar spine condition, muscle strength and range of motion of extremity joints, and peripheral arterial pulses.

5.1.2.3 Laboratory Tests: Including complete blood count, urinalysis, blood biochemistry, inflammatory markers, coagulation function, glycated hemoglobin, B-type natriuretic peptide (BNP), and other relevant tests.

5.1.2.4 Ancillary Tests: Including ECG, abdominal ultrasound, urinary system ultrasound, post-void residual urine ultrasound, echocardiography, chest CT, and body composition analysis.

5.1.3 Functional Impairment Assessment **5.1.3.1 Elderly Capacity Assessment:** Conducted according to GB/T 42195-2022 requirements, with capacity grading and assessment reports documented in paper or electronic records.

5.1.3.2 Exercise Capacity Assessment: Using the 6-minute walk test, timed up-and-go test, and Short Physical Performance Battery Protocol (SPPB) to evaluate exercise capacity.

5.1.3.3 Psychological and Cognitive Function Assessment: Psychological function evaluated using the Hamilton Anxiety/Depression Scale or Self-Rating Anxiety/Depression Scale; cognitive function assessed using the Mini-Mental State Examination (MMSE) or Montreal Cognitive Assessment (MoCA).

5.1.3.4 Activities of Daily Living (ADL)/Quality of Life Assessment:

Commonly used scales include the Barthel Index, Functional Independence Measure (FIM), Functional Activities Questionnaire (FAQ), and the MOS Item Short Form Health Survey (SF-36).

5.2 Rehabilitation Implementation Plan

5.2.1 Rehabilitation Principles To promote recovery in AKI-GC patients, rehabilitation should be initiated early, timely, and comprehensively. Rehabilitation goals should be established with phase-specific protocols for the critical ICU period, general ward hospitalization, and post-discharge recovery. Individualized rehabilitation plans should be developed based on patient age, comorbidities, functional impairments, family support, and education level [12].

5.2.2 Rehabilitation Goals **5.2.2.1 ICU Critical Period:** Goals focus on maintaining bodily functions, promoting renal function recovery, and improving physiological, psychological, and cognitive impairments.

5.2.2.2 General Ward Hospitalization: Goals focus on promoting renal function recovery, preventing complications, and reducing functional dependence.

5.2.2.3 Post-Discharge Recovery: Goals focus on improving quality of life and facilitating return to family and society.

5.2.3 Rehabilitation Protocol for AKI-GC Patients in ICU **5.2.3.1 General Approach:** Critically ill AKI-GC patients without contraindications should receive at least passive rehabilitation. For conscious and cooperative patients, gradual transition from passive to active rehabilitation is recommended, combined with appropriate nutritional strategies, psychological and cognitive interventions, speech rehabilitation, and rehabilitation nursing to minimize functional impairments and dependence.

5.2.3.2 Timing of Intervention: Rehabilitation should begin once hemodynamics and respiratory function have stabilized, with the following recommended criteria [13-14]: (1) heart rate 50–120 beats/min; (2) systolic blood pressure 100–160 mmHg (1 mmHg = 0.133 kPa), diastolic pressure $ $100 mmHg, mean arterial pressure 65–110 mmHg; (3) respiratory rate $ $30 breaths/min, oxygen saturation $ 90*{2}$ $ $60%, PEEP $* $10cmH{2}$O; (4) during extended life support, low-dose vasoactive medication support with dopamine $ $10\mu g \cdot kg^{\{-1\}\cdot min}\{-1\}$ or norepinephrine/epinephrine $ $0.1\mu g \cdot kg^{\{-1\}\cdot min}\{-1\}$; (5) rehabilitation timing during renal replacement therapy [15-16]: for hemodialysis, rehabilitation should be scheduled 1–2 hours after initiation; for continuous renal replacement therapy (CRRT), 4–6 hours after initiation; for peritoneal dialysis, with <500 mL dialysate in the abdomen or during dry abdomen.

5.2.3.3 Rehabilitation Measures: Progressive rehabilitation from passive to active exercise is recommended [17-18], including: passive joint mobilization,

stretching, proper positioning, tilt table training, passive bedside cycling, neuromuscular electrical stimulation. For conscious and cooperative patients, active rehabilitation should be combined, including: breathing exercises, swallowing training, bedside resistance exercises, active cycling in bed, supine gymnastics, bedside sitting/standing balance training, weight shift training, assisted walking, functional electrical stimulation, and active exercise combined with functional electrical stimulation-assisted circulation.

5.2.3.4 Precautions: (1) **Exercise principles:** Start with low intensity, progress gradually, and maintain consistency. For bedridden patients requiring position changes, gradually increasing angles should be used to avoid orthostatic hypotension, with protection of vascular access. (2) **Exercise prescription:** Follow the FITT-VP principle (Frequency, Intensity, Time, Type, Volume, Progression) for individualized prescription [7,19]. A Borg Rating of Perceived Exertion score of 11–13, with 1–2 sessions/day and 1–3 sets/session, is more suitable for critically ill patients [20]. (3) **Monitoring:** Rehabilitation should be implemented with close monitoring of blood pressure, heart rate, and oxygen saturation, including pre-exercise education, guidance and supervision during exercise, and post-exercise vital sign monitoring to prevent adverse events. (4) **Contraindications:** Include uncontrolled hypertension or hypotension, uncorrected acute left heart failure and/or NYHA Class IV chronic heart failure, potentially fatal arrhythmias (including sustained ventricular tachycardia), recent myocardial infarction, unstable angina, severe pericardial effusion, active liver disease, uncontrolled diabetes, severe cerebrovascular disease, peripheral vascular disease, persistent pre-dialysis hyperkalemia and/or severe metabolic acidosis.

5.2.3.5 Nutritional Strategy [21]: After assessing energy and protein requirements, caloric intake of 20–30 $\text{kcal} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$ is recommended, starting with low-calorie nutrition not exceeding 70% of energy expenditure (EE), gradually increasing to 80%–100% of EE to avoid both under- and over-feeding. Protein intake recommendations during the critical phase are: for patients not receiving renal replacement therapy, start at 0.8–1.0 $\text{g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$, increasing to 1.3 $\text{g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$ if tolerated; for intermittent renal replacement therapy, 1.0–1.5 $\text{g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$; for CRRT or hypercatabolic patients, 1.5–1.7 $\text{g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}$.

5.2.3.6 Rehabilitation Nursing: For bedridden patients, enhanced rehabilitation nursing is essential, including positioning management, prone positioning for sputum drainage, swallowing and feeding care, artificial airway management, and bladder care.

5.2.3.7 Psychological Rehabilitation: Patient psychological changes and feelings should be closely monitored. For conscious patients, rehabilitation goals should be negotiated and agreed upon to ensure cooperation. When patients cannot actively participate in plan development, family members or caregivers should be encouraged to participate actively in developing and implementing rehabilitation management [22]. Psychological interventions include pharmacotherapy, cognitive behavioral therapy, and music therapy.

5.2.4 Rehabilitation Protocol for AKI-GC Patients in General Ward
5.2.4.1 Education: Content includes daily dietary management, fluid intake/output management, self-management of AKI complications, benefits and risks of kidney disease rehabilitation, functional assessment considerations, psychological adjustment, and family/social support.

5.2.4.2 Rehabilitation Measures: Including passive joint mobilization, stretching, proper positioning, tilt table training, breathing exercises, swallowing training, bedside resistance exercises, active/passive cycling, isokinetic muscle training, supine-to-standing gymnastics, bedside sitting/standing balance training, weight shift training, assisted walking, ADL training, fine hand motor training, air pressure wave therapy, infrared thermotherapy, functional electrical stimulation, active exercise combined with functional electrical stimulation-assisted circulation, and psychological, cognitive, speech, and music rehabilitation.

5.2.4.3 Exercise Prescription: Exercise rehabilitation should include warm-up, main exercise, and cool-down/stretching. Early rehabilitation should combine active and passive exercises, encouraging active participation. Intensity should be controlled at Borg score 11–13. Prescription should follow the FITT-VP principle based on the *Expert Consensus on Exercise Rehabilitation for Adult Patients with Chronic Kidney Disease in China* [15], as detailed in Table 2 .

5.2.4.4 Nutritional Management: Amino acid conversion rates in AKI-GC patients increase progressively during recovery, so protein intake should gradually increase to 1.3 $g \cdot kg^{-1} \cdot d^{-1}$. The optimal energy-to-nitrogen ratio during AKI has not been established [23]. Electrolyte levels should be closely monitored.

5.2.4.5 Psychological Rehabilitation: Clinician-patient communication should employ appropriate techniques to build strong therapeutic relationships, enabling active patient cooperation. Patients with psychological dysfunction may benefit from group interventions in addition to pharmacotherapy, where mutual support, shared training, and open communication can rekindle interest in life and restore social role function.

5.2.5 Rehabilitation Protocol for AKI-GC Patients in Post-Discharge Recovery 5.2.5.1 Rehabilitation Principles: Unsupervised post-discharge rehabilitation should first encourage patients to progressively increase daily activities. Unsupervised home exercise prescriptions should be simple, safe, and sustainable long-term (20–60 min/session, 3–5 times/week).

5.2.5.2 Education: Before prescribing home exercise, patients and families should receive education on exercise rehabilitation, including proper use of the Borg scale to monitor intensity, safety precautions, and the family' s role in support, supervision, and guidance.

5.2.5.3 Home Exercise Procedure: Measure blood pressure and pulse before

exercise. Choose flat, obstacle-free locations, and exercise 1–2 hours after meals. Begin with 5–10 minutes of warm-up to gradually prepare joints, ligaments, and muscles. The main exercise should last >20 minutes, but can be performed in 5–10 minute intervals with 3–5 minute rest periods, gradually increasing duration and intensity as cardiopulmonary capacity improves [24]. End with 5–10 minutes of cool-down. Resistance training sessions should be spaced at least one day apart. Exercises may include seated leg extensions, semi-recumbent hip flexion, supine straight leg raises, and standing calf raises, starting against gravity and progressing to external resistance using elastic bands, sandbags, or dumbbells. Flexibility training should be performed daily. Balance training (e.g., Baduanjin, Tai Chi, yoga) 2–3 times weekly can reduce fall risk. Measure heart rate and blood pressure 3–5 minutes after exercise.

5.2.5.4 Safety Precautions: (1) Postpone exercise during acute metabolic complications such as severe hypoglycemia or diabetic ketoacidosis; (2) Diabetic patients or those prone to hypoglycemia should measure blood glucose before, during, and after exercise, with high-glycemic index foods readily available; (3) Avoid swimming and weight-bearing exercise with open wounds or unhealed ulcers; (4) Instruct patients to avoid Valsalva maneuvers, particularly during resistance training; (5) Report persistent hypotension or other discomfort to physicians; (6) Report significant blood pressure elevation during exercise (systolic $ $180 mmHg); (7) Report signs of excessive intensity including persistent fatigue, nausea, dyspnea, unrelieved severe fatigue, insomnia, muscle/joint pain affecting daily activities, or significant chest tightness/pain.

5.2.5.5 Supervision: Monitor home exercise implementation through exercise diaries, pedometers, or family accompaniment to encourage adherence.

6 Service Evaluation and Quality Control

6.1 Assessment Content

A scientific personnel and service evaluation mechanism should be established, with assessment content categorized into three domains: organizational management, service management, and outcomes.

6.1.1 Organizational Management assesses MDT establishment, clear role definitions, completeness of rehabilitation service systems, staffing, and professional training qualification rates.

6.1.2 Service Management assesses compliance with service indicators, including standardization and timeliness of rehabilitation assessments and individualized implementation rates of rehabilitation treatment plans.

6.1.3 Outcomes assesses actual service effectiveness, including renal function recovery rates (e.g., proportion of patients with improved AKI stage), functional improvement rates (e.g., SPPB and MMSE score improvements), and patient/family satisfaction.

6.2 Assessment Indicators

6.2.1 Standardized Rehabilitation Management Rate = (Number of patients completing rehabilitation assessment and intervention per protocol / Total number of AKI-GC patients managed annually) × 100%.

6.2.2 Functional Improvement Rate = (Number of patients with improved exercise capacity or cognitive function at follow-up compared to baseline / Total number of AKI-GC patients managed annually) × 100%.

6.2.3 Patient Satisfaction Rate = (Number of patients satisfied with rehabilitation services / Total number of patients surveyed) × 100%.

6.3 Assessment Methods

6.3.1 Multi-dimensional Assessment: Evaluate service standardization through site visits, medical record reviews, and equipment verification; extract rehabilitation assessment and treatment data through information systems; and conduct independent patient satisfaction surveys or expert reviews.

6.3.2 Dynamic Feedback and Improvement: Quarterly compilation of assessment results into analysis reports feedback to the team; development of improvement plans targeting weak areas with enhanced training or process optimization.

6.4 Quality Control

6.4.1 Standardized Procedures: Develop unified assessment manuals with clear scoring criteria and establish quality control groups for regular accuracy verification.

6.4.2 Expert Involvement: Form review panels comprising nephrology, rehabilitation, and geriatrics experts; train reviewers before assessments to ensure consistent evaluation standards.

6.4.3 Continuous Improvement Mechanism: Establish complaint and suggestion channels for timely processing and service enhancement.

7 Conclusion

This specification systematically constructs a full-cycle rehabilitation service system for AKI-GC patients, establishing core principles of multidisciplinary collaboration, phase-specific rehabilitation, and personalized intervention. It covers rehabilitation assessment, exercise prescription, nutritional support, psychological intervention, and rehabilitation nursing, with a scientific evaluation and quality control mechanism. The development and implementation of this specification will promote the standardization of rehabilitation services for elderly patients with comorbidity and acute kidney injury, providing an impor-

tant practical framework for comprehensive AKI management in the context of China' s aging population.

Primary Drafting Unit: Kidney Disease Rehabilitation Center, Beijing Boai Hospital, China Rehabilitation Research Center; Committee of Kidney Disease Rehabilitation, Chinese Association of Rehabilitation Medicine

Primary Drafters: Wang Tingting (Kidney Disease Rehabilitation Center, Beijing Boai Hospital, China Rehabilitation Research Center), Lin Zehua (Kidney Disease Rehabilitation Center, Beijing Boai Hospital, China Rehabilitation Research Center), Ma Yingchun (Kidney Disease Rehabilitation Center, Beijing Boai Hospital, China Rehabilitation Research Center), Ao Qiangguo (Department of Nephrology, Second Medical Center, Chinese PLA General Hospital), Bai Yun (Geriatric Nephrology, First Affiliated Hospital of Nanjing Medical University), Bian Xueyan (Department of Nephrology, Ningbo First Hospital), Cao Pengyu (Department of Nephrology, Third Affiliated Hospital of Nanjing University), Chen Guanglei (Beidaihe Rehabilitation and Convalescence Center, Joint Logistics Support Force, Chinese PLA), Chen Jing (Department of Geriatrics, Zhongnan Hospital of Wuhan University), Chen Limeng (Department of Nephrology, Peking Union Medical College Hospital), Chen Ling (Department of Geriatrics, Zhongnan Hospital of Wuhan University), Chen Menghua (Department of Nephrology, General Hospital of Ningxia Medical University), Chen Yuqing (Department of Nephrology, First Hospital of Peking University), Cheng Qingli (Department of Nephrology, Second Medical Center, Chinese PLA General Hospital), Gan Liangying (Department of Nephrology, Peking University People' s Hospital), Gao Ping (Department of Nephrology, Zhongnan Hospital of Wuhan University), Guo Minghao (Nephrology Hospital, First Affiliated Hospital of Xinxiang Medical University), Guo Qi (School of Rehabilitation Medicine, Shanghai University of Medicine and Health Sciences), He Qiang (Zhejiang Provincial Hospital of Traditional Chinese Medicine), Hu Zhao (Department of Nephrology, Qilu Hospital of Shandong University), Hui Haipeng (Department of Cardiology, First Medical Center, Chinese PLA General Hospital), Jiang Hongli (Blood Purification Department, First Affiliated Hospital of Xi' an Jiaotong University), Jiang Xia (Department of Nephrology, Second People' s Hospital of Nantong), Li Guisen (Department of Nephrology, Sichuan Provincial People' s Hospital), Li Guiying (Department of Nephrology, Affiliated Hospital of Hebei University of Engineering), Li Han (Department of Nephrology, Chaoyang Hospital Affiliated to Capital Medical University), Li Hong (Blood Purification Center, Hainan Provincial People' s Hospital), Li Yancun (Department of Nephrology, Daxing District Hospital of Integrated Traditional Chinese and Western Medicine, Beijing), Ma Yingchun (Department of Nephrology, Beijing Boai Hospital, China Rehabilitation Research Center), Mao Huijuan (Department of Nephrology, Jiangsu Provincial People' s Hospital), Pei Huaying (Second Hospital of Hebei Medical University), Peng Hongying (Baiyun Hospital, Guizhou Medical University), Shen Lin (Department of Geriatric Cardiology,

Qilu Hospital of Shandong University), Shen Ying (Department of Nephrology, First People' s Hospital of Yunnan Province), Su Haihua (Department of Endocrinology and Nephrology, CNOOC Hospital, Peking University), Sun Fuyun (Department of Nephrology, Cangzhou Central Hospital), Tang Ying (Department of Nephrology, Third Affiliated Hospital of Southern Medical University), Tian Na (Department of Nephrology, General Hospital of Ningxia Medical University), Wang Caili (First Affiliated Hospital of Baotou Medical College, Inner Mongolia University of Science and Technology), Wang Jiaying (Department of Nephrology, Suzhou Science and Technology Town Hospital), Wang Jing (Department of Nephrology, Luohu District Traditional Chinese Medicine Hospital, Shenzhen), Wang Song (Department of Nephrology, Third Hospital of Peking University), Xia Peng (Department of Nephrology, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences), Xie Ying (Department of Rehabilitation Medicine, Beijing Friendship Hospital Affiliated to Capital Medical University), Xing Guangqun (Department of Nephrology, West Coast Campus, Affiliated Hospital of Qingdao University), Xu Jinsheng (Fourth Hospital of Hebei Medical University), Yang Zhenhua (First Affiliated Hospital of Guangxi Medical University), Yao Li (First Affiliated Hospital of China Medical University), Ye Wenling (Department of Nephrology, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences), Yong Zhenzhu (Geriatric Nephrology, First Affiliated Hospital of Nanjing Medical University), Yu Chen (Department of Nephrology, Tongji Hospital Affiliated to Tongji University), Zhang Aihua (Department of Nephrology, Xuanwu Hospital Affiliated to Capital Medical University), Zhang Dongliang (Department of Nephrology, Beijing Jishuitan Hospital), Zhang Guojuan (Department of Nephrology, Tongren Hospital Affiliated to Capital Medical University), Zhang Xinzhou (Department of Nephrology, Shenzhen People' s Hospital), Zhang Yue (Shenzhen Hospital of Peking University), Zhao Ban (Department of Nephrology, Beijing Hospital), Zhao Jiahui (Department of Nephrology, Second Medical Center, Chinese PLA General Hospital), Zhao Weihong (Geriatric Nephrology, First Affiliated Hospital of Nanjing Medical University), Zhao Xiaoyi (Department of Nephrology, Affiliated Hospital of Chifeng University, Inner Mongolia), Zhao Yingying (Department of Nephrology and Rheumatology, Second Affiliated Hospital of Zhengzhou University), Zhao Zhanzheng (First Affiliated Hospital of Zhengzhou University), Zhong Aimin (Department of Nephrology, Jiangxi Provincial People' s Hospital), Zhong Hongbin (Department of Nephrology, Fifth Hospital of Xiamen), Zhou Yun (Department of Nephrology, First Hospital of Shanxi Medical University)

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Note: Figure translations are in progress. See original paper for figures.