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COMMENTARY

Involuntary Falls in Patients with Chronic Kidney Diseases on Nephrology Wards: Research Advances and Future Perspectives

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Background: Nephrology nursing faces an inevitable challenge when it comes to falls. This study aims to review existing literature on falls in chronic kidney disease (CKD) patients and to discuss potential solutions.

Methods: This review explores the characteristics and causes of falls in CKD patients, elucidate the underlying mechanisms, shares better nursing practices, and discusses both current prevention strategies as well as potential future interventions.

Results: CKD patients often experience consciousness impairment and motor dysfunction due to factors such as muscle atrophy, nerve damage, malnutrition, anemia, fluid-electrolyte imbalances, hormonal disorders, and dialysis. Additionally, this study not only shares insights from nursing experience with these patients, but also reviews current evidence-based fall prevention strategies and proposes potential new interventions that could be tested in future research.

Conclusion: CKD may increase the risk of involuntary falls in patients due to consciousness impairment and motor dysfunction. Advocating for a standardized expert consensus on fall risk assessment and comprehensive care for CKD patients would enhance the nursing framework in nephrology wards and help patients decrease their fall risk and elevate their quality of life.

Keywords: falls, chronic kidney diseases, dialysis, nephrology nursing, anemia

Introduction

Falls among hospitalized patients represent a prevalent and consequential adverse event, capable of causing severe physical harm such as fractures, head trauma, and soft tissue injuries.[1,2] Additionally, they can significantly impact a patient's self-esteem and confidence, potentially leading to long-lasting psychological trauma.[3,4] Approximately one-third of individuals over the age of 65 experience a fall each year.[5] Within this age bracket, chronic kidney disease (CKD) increases the rate of falls by 1.81 times.[6] Moreover, middle-aged adults with CKD had a higher likelihood of falling (2.30, 95% CI 2.07–2.55) and sustaining fall-related injuries (1.54, 95% CI 1.32–1.80) compared to those without CKD.[7] Several factors contribute to the increased fall risk in CKD patients, including osteoporosis, anemia, water-electrolyte imbalances, blood pressure fluctuations, toxin accumulation, muscle atrophy, and nerve damage.[8–13] For this reason, they commonly exhibit motor dysfunction and impaired subjective consciousness, rendering them unable to effectively maintain balance.[10,14] Furthermore, hospital-specific factors such as physical deterioration and medication-related side effects can further heighten the risk of falls.[15,16] Consequently, preventing falls among patients with CKD is a crucial responsibility in nephrology nursing.[17,18]

To optimize patient care, a series of studies on this issue were conducted, proposing several preventive measures that have effectively reduced the rate of fall injuries.[14] Yet, sporadic falls among CKD patients persist, underscoring the need

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for improved fall prevention strategies in nephrology care. This study aims to analyze the dominant characteristics and causes of fall injuries in CKD patients, understand their underlying mechanisms, share nursing expertise, and investigate potential advancements in prevention methods and interventions. This knowledge will serve as a foundation for the continued development of nephrology nursing strategies.

Characteristics of Falls in CKD Patients

High-Risk Groups

CKD affects a wide demographic, but the risk of falls is not uniformly distributed across all patients. The prevailing consensus suggests that individuals with advanced CKD face a higher risk of falling.[19–21] The exact reasons will be detailed in subsequent sections. Also, the elderly group is at high risk, which may be related to their weaker physical functioning.[4,7,22] Moreover, there have been several studies that have identified risk factors associated with falls in CKD patients,[2,23] but all have been related to the course of CKD and age. Although CKD encompasses a range of primary conditions and complications, there's a lack of comprehensive research exploring the relationship between these conditions and fall risk. This leaves a gap in our understanding of which CKD subgroups are most prone to falls. In clinical practice, assessments are routinely conducted to identify patients with elevated fall risks. Common evaluation methods involve measuring muscle strength using a grip strength device and evaluating the patient's mental state. Patients presenting with diminished muscle strength, depression, anxiety, and recurrent episodes of subjective confusion are deemed to be at a higher risk of falls.[24–26]

Spatio-Temporal Characteristics of Falls

Hospitalized CKD patients exhibit specific areas prone to falls, such as toilets and bathrooms.[14,26] The act of standing and walking to restrooms can pose a fall risk, often due to unstable legs or a sudden drop in blood pressure. Slippery surfaces in bathrooms, especially during showers, further compound the risk. Additionally, walking, whether within the ward or the hospital corridor, is a common scenario for falls. Factors such as unsteady gait, visual impairment, and misuse of walking aids intensify this risk. Falls are also prevalent during actions like turning, standing up, transferring, or shifting, often stemming from physical instability and uncoordinated movements.[27] These findings emphasize the importance of prioritizing fall prevention in restrooms, hallways, and bedside areas, advising patients against abrupt postural changes, and encouraging them to request assistance when needed.

In terms of timing, falls in hospitalized CKD patients tend to be concentrated during nighttime and early morning hours. There's a heightened frequency of falls at night, possibly because patients tend to be less alert.[14] Moreover, patients might experience dizziness upon rising, which may be closely linked to postural hypotension.[27] Given these trends, enhancing monitoring during the night and early morning hours can help promptly detect and respond to falls. As such, healthcare institutions and professionals should adopt preventive measures tailored to each patient's unique situation. Possible strategies include offering appropriate mobility aids, intensifying nursing rounds, and installing bedside alarms. These actions aim to effectively mitigate the risk of falls among hospitalized patients.

Summary

From the insights presented (Figure 1), it is evident that preventive measures are paramount for CKD patients, especially those in advanced stages or with nephrotic syndrome. Ensuring patient safety by improving the living environment is vital, both at home and in the hospital. This entails keeping pathways clear, minimizing clutter, ensuring dry floors, and using non-slip mats. Furthermore, to further mitigate fall risks, patients and their families should also be educated about home safety precautions.

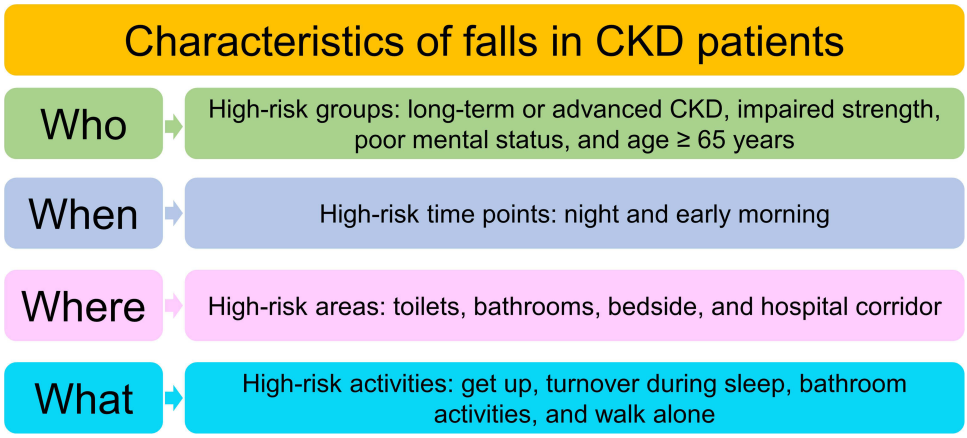

Figure 1 Who, when, where, and what activities are at high-risk for falls in CKD patients.

Reasons and Mechanisms of Falls in CKD Patients (Figure 2)

Muscle Atrophy

A critical facet of motor impairment is muscle atrophy, which can be attributed to several intertwined factors. First, CKD results in the accumulation of metabolites, which results in increased protein breakdown and reduced synthesis, culminating in muscle tissue breakdown and atrophy.[28,29] Second, CKD disrupts glucose, fat, and protein metabolism, leading to insufficient energy supply and subsequent muscle tissue atrophy.[30,31] Third, CKD induces chronic inflammatory and oxidative stress, triggering the release of inflammatory factors that inhibit protein synthesis and promote protein catabolism, ultimately resulting in muscle atrophy.[28,31] Lastly, CKD patients often experience fatigue, weakness, and reduced exercise endurance, which restricts physical activity and exacerbates muscle atrophy. Therefore, it is imperative for CKD patients to ensure optimal nutritional uptake, embrace moderate physical activity, and lay emphasis on muscle fortification. Tailored supplementation and nutritional interventions are equally pivotal to safeguarding muscle vitality.

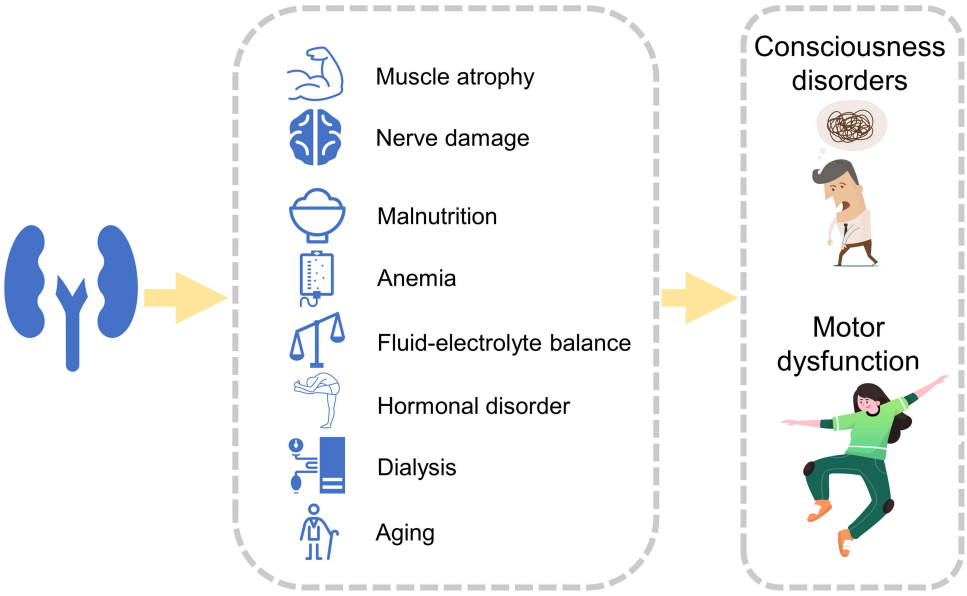

Figure 2 Schematic illustration of the reasons and mechanisms of falls in CKD patients. These images are our originals, and the icons in them are freely available icons, originating from WPS office software.

Nerve Damage

Nerve damage and functional abnormalities play a pivotal role in motor dysfunction and impaired subjective consciousness in CKD patients.[6,25] Several principal factors underlie this phenomenon. Firstly, the accumulation of toxins resulting from uremia directly impacts the nervous system.[32] Secondly, the accumulation of toxins incites an inflammatory response, releasing inflammatory mediators like cytokines and oxygen-free radicals, which can compromise nerve cell structure and function.[33] Thirdly, CKD-associated malnutrition hampers the adequate supply of nutrients to nerve cells, thereby affecting their function.[34] Lastly, CKD patients often undergo long-term treatment with various medications, some of which may have adverse effects on the nervous system.[35] Overall, these factors collectively contribute to the structural and functional damage of nerve cells.

Malnutrition

Malnutrition is a common concern among CKD patients, manifesting in symptoms such as weakness and fatigue.[24] This emerges from an interplay of various factors. First, CKD patients often experience a loss of appetite, which can be attributed to abnormalities in taste and smell senses caused by uremia, as well as the impact of metabolite accumulation on the central nervous system.[36,37] Second, vomiting and nausea are prevalent among CKD patients, often caused by metabolite buildup and medication side effects.[38–40] Third, digestive complications, including diarrhea and constipation, frequently afflict CKD patients. Arising from electrolyte imbalances, medication side effects, or disrupted bowel function, these complications obstruct the effective absorption and digestion of vital nutrients.[41] Fourth, CKD patients may experience proteinuria, characterized by the excessive loss of protein through urine.[42] Protein is a vital nutrient for maintaining normal physiological function, and its restriction contributes to a decline in nutritional status.[43] The task of restricting protein intake and enhancing absorption has been particularly challenging. Addressing this nutritional challenge requires a careful approach to nutritional management. Despite extensive research on nutrition for individuals with CKD, there is limited practical application. There is a prevailing preference for pharmacological interventions, as they are perceived as more effective in improving a single nutritional indicator.

Anemia

Anemia, a frequent complication in CKD patients, which can induce fatigue, weakness, and breathlessness, thereby compromising physical mobility and equilibrium and elevating fall susceptibility. First, Impaired kidney function leads to reduced erythropoietin (EPO) secretion, which is an essential hormone governing erythropoiesis, resulting in decreased erythropoiesis and subsequent anemia.[39,44] Second, CKD patients often exhibit iron metabolism disorders, including impaired iron absorption, abnormal transportation, and reduced storage, leading to inadequate iron supply and affecting erythropoiesis.[44,45] Third, CKD patients frequently experience chronic inflammatory responses, which can encumber erythropoiesis and truncate the lifespan of red blood cells.[46–49] Fourth, the accumulation of metabolites, such as urea and creatinine, adversely affects bone marrow hematopoiesis and inhibits erythropoiesis.[50,51] Fifth, malnutrition can impact the production and function of red blood cells.[52] Therefore, recognizing and addressing anemia with alacrity is paramount for CKD patients. Treatment options for anemia include EPO replacement therapy, iron supplementation, and red blood cell transfusion.

Fluid and Electrolyte Balance

CKD impairs the kidney's aptitude for water and electrolyte regulation, resulting in imbalances that can disrupt nerve and muscle regulation. For instance, sodium retention can induce hypertension and edema, while hyperkalemia can have detrimental effects on cardiac function, posing potential life-threatening risks.[11,53–56] Hyperphosphatemia and hypocalcemia can lead to abnormal mineral metabolism and osteoporosis.[9] Abnormal blood potassium, hyponatremia, and hypocalcemia can give rise to symptoms like muscle twitching, limb weakness, and numbness. Additionally, CKD patients may develop acidosis or alkalosis, further disrupting this equilibrium.[57] Therefore, meticulous monitoring and management of these imbalances in CKD care is indispensable. Developing an individualized treatment plan tailored to

the patient's specific condition is essential, which may involve limiting fluid intake, controlling dietary sodium, potassium, and phosphorus intake, and utilizing medications as necessary.

Hormonal Disorder

CKD can induce various hormonal dysfunctions, ultimately impacting the body's mobility. For instance, CKD stimulates the release of parathyroid hormone (PTH) from the parathyroid glands.[58] PTH primarily enhances intestinal calcium absorption, inhibits renal tubular reabsorption of phosphate, and promotes calcium release from bones. This cycle perpetuates and culminates in hyperparathyroidism. Parathyroid excision can significantly improve negative physical and psychological symptoms and enhance the quality of life.[59] Despite the high effectiveness of this procedure in treating the aforementioned conditions, it is essential to acknowledge the existence of potential risks and hazards. One notable risk is the development of hypocalcemia following parathyroidectomy,[60] which can manifest as muscle spasms, neurological complications, cardiac arrhythmias, and in severe instances, life-threatening situations. Consequently, the implementation of postoperative calcium and vitamin D supplementation therapy becomes imperative.

Moreover, CKD is associated with the synthesis and metabolism of thyroid hormones, such as hypothyroidism or hyperthyroidism.[12,61,62] Hypothyroidism is characterized by reduced levels of thyroxine (T3 and T4) and elevated levels of thyroid-stimulating hormone (TSH), manifesting symptoms such as fatigue, weight gain, and constipation. Conversely, hyperthyroidism is characterized by increased thyroxine levels and decreased TSH levels, resulting in symptoms like palpitations, weight loss, and excessive perspiration.

Additionally, CKD may impact the synthesis and secretion of growth hormones, leading to either deficiencies or excesses.[12] Growth hormone deficiency affects the growth and development of children, while excessive growth hormone supplementation can result in conditions like gigantism or acromegaly.[63] It is essential to highlight that CKD-induced hormone dysfunction is a complex process potentially involving abnormalities in various hormones. The specific circumstances and implications of this dysfunction should be determined based on the individual patient's condition and hormone levels.

Dialysis

Patients are susceptible to falls following dialysis due to several potential reasons. First, dialysis can result in hypotension or hypertension manifesting as dizziness and vertigo.[10] Second, dialysis can further exacerbate CKD-induced muscle atrophy and weakness.[64] Third, dialysis can accelerate the loss of calcium.[9,64] Fourth, there is a high probability that dialysis will cause hypoglycemia.[65] Lastly, patients may require medications like anti-hypertensives and diuretics during dialysis, which can induce side effects such as hypotension and dizziness. Consequently, patients are typically advised to rest and gradually adjust their posture before leaving the bed after dialysis to minimize the risk of falls.

Aging

Apart from the aforementioned factors, aging is another factor contributing to an increased susceptibility to falls among the elderly.[66] As age advances, there is a gradual decline in physical function and balance, weakened muscle strength, slower reaction time, and impaired vision and hearing, all of which collectively elevate the risk of falling. Moreover, the elderly often experience conditions such as muscle atrophy and osteoporosis, rendering their muscles and bones fragile and more susceptible to injury. Additionally, conditions like arthritis can result in reduced joint mobility, further augmenting the likelihood of falls.[67] However, it is essential to note that the relationship between age-associated falls and CKD-associated falls is not absolute, albeit there may be a correlation. This is primarily because aging inherently leads to a decline in kidney function and other organ functions. Moreover, elderly individuals with CKD may have a history of long-term CKD accompanied by multiple complications. Irrespective of the underlying cause, it is imperative to acknowledge that elderly CKD patients constitute a high-risk group for falls and therefore require specialized attention and care.

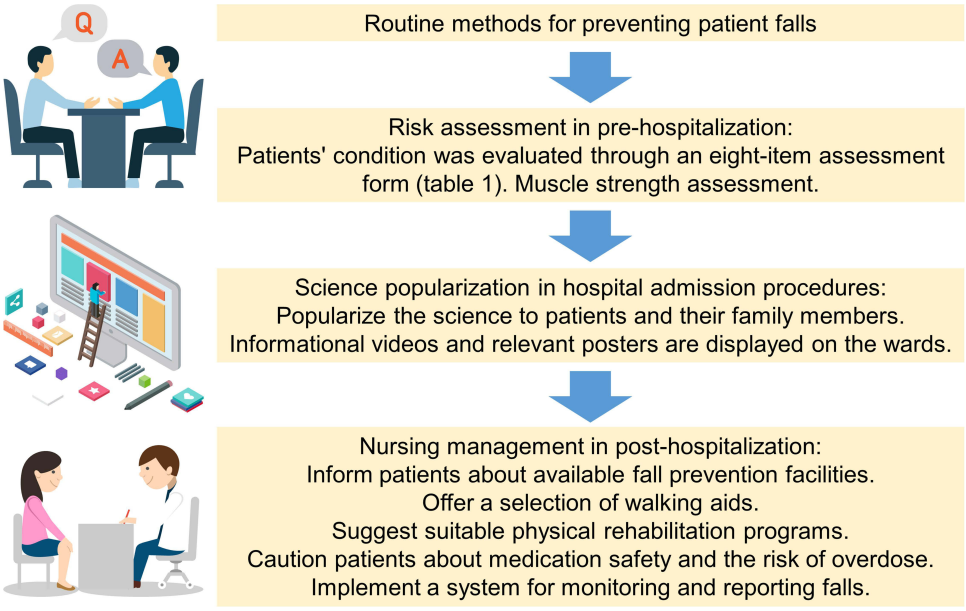

Figure 3 A set of assessment and prevention strategies to reduce fall risk in CKD patients These images are our originals, and the icons in them are freely available icons, originating from WPS office software.

Methods of Fall Prevention and Management in Wards

Fall prevention is a vital concern in nephrology nursing, and hospitals employ various strategies to ensure patient safety and well-being. These strategies encompass holistic patient assessment, monitoring, furnishing of apt amenities, medication management, and a robust emphasis on patient education and training. In this section, we present our management experience spanning over two decades, spanning domains such as risk assessment, science popularization, and nursing management (Figure 3).

Risk Assessment

For efficacious fall prevention, a comprehensive fall risk assessment was performed on each patient before admission (Table 1). This assessment will encompass factors such as age, health condition, medication usage, mobility, cognitive function, and other relevant considerations to determine the patient's susceptibility to falls. Additionally, the patient's vital signs, including blood pressure and heart rate, were continuously monitored to detect any abnormalities, such as

Table 1 Criteria for Assessing Fall Risk in CKD Patients

Criteria for Assessing Fall Risk in CKD Patients	
Property	Standard
Age	≥ 65 years
History of falls	Six months prior to admission
Subjective consciousness disorders	Depression, irritability, hallucinations, Alzheimer's disease
Motor dysfunction	Limb weakness, deformity, paralysis, limited mobility
Cardiovascular function abnormalities	Hypoglycemia, abnormal blood pressure, arrhythmia
Sensory impairment	Reduced visual or auditory abilities
Toileting frequency	≤ 2 hours
Treatment and comorbidities	Surgery, seizures, flipping over fences, taking sedatives

Notes: According to the aforementioned eight scoring criteria, meeting two-point suggests a potential risk of falling, while meeting three-point is indicative of a high risk of falling. However, it is important to consider that patients with CKD, particularly those in CKD stage five, undergoing dialysis, or experiencing nephrotic syndrome, may not experience a pronounced sensation of limb weakness due to the long-term nature of their chronic condition or the presence of edema. Consequently, relying solely on the risk assessment score may not accurately reflect the true risk of falling for these patients.

hypotension, in a timely manner. In cases where patients exhibit higher risk scores, persistent reminders to both the patients and their caregivers about the latent fall risks are crucial. This also involves equipping them with foundational knowledge to amplify awareness and bolster future preventive tactics.

Science Popularization

In fall prevention, educating patients and their families about fall-related knowledge is a vital component.[68] This education includes teaching correct mobility skills, safety precautions, measures, and protocols for handling emergencies such as falls. Given the age and potential cognitive challenges of many CKD patients, educating family members often proves more effective than directly instructing the patients. We actively encourage the involvement of the patient's family members in fall prevention efforts, such as assisting the patient with movement and reminding them to prioritize safety. A variety of methods were used to widen the outreach of fall prevention knowledge, including conducting educational discussions with patients, displaying informative videos in patient rooms periodically, and placing posters in corridors. Using these methods to prevent falls is both straightforward and effective.

Nursing Management

The provision of assistive devices is fundamental to fall prevention. For example, the installation of various safety facilities, such as handrails, non-slip flooring, and guardrails to offer support and protection for patient mobility. For patients with mobility challenges, supportive aids such as crutches and walkers are also available to enhance their stability and mobility. Additionally, the use of exoskeletons to facilitate rehabilitation training for patients with muscle weakness is also an option. Effective patient medication management is another pivotal facet of fall prevention, ensuring to sidestep drugs that may precipitate adverse effects, such as hypotension or dizziness. Furthermore, some places have established a comprehensive fall monitoring and reporting system to promptly record and analyze fall incidents, enabling nurses to identify areas for improvement and implement preventive measures. This innovative approach lays the groundwork for future endeavors in precision medicine and bespoke fall prevention methodologies.

Hot Topics in Fall Prevention Research and Future Outlook

While these measures have proven to be highly effective in reducing fall incidences among nephrology inpatients, falls still occur. To address this persisting challenge, researchers have developed additional modalities that have demonstrated effectiveness in preventing patient falls (Figure 4).

Figure 4 Hot topics in fall prevention research and future outlook. These images are our originals, and the icons in them are freely available icons, originating from WPS office software.

Convalescent Training

Engaging in appropriate exercise can effectively enhance a patient's balance, muscle strength, and flexibility, consequently reducing the risk of falls.[69,70] For example, incorporating balance training exercises can improve patients' sense of balance and control. Examples of such exercises include standing on one foot, walking along a tracing line, and performing exercises with closed eyes. Muscle-strengthening exercises can enhance patients' muscle strength, thereby improving stability while walking and standing. Examples of these exercises include weightlifting, squatting, and wall-resistance exercises. Likewise, flexibility training aids in maintaining optimal joint mobility and body movement. Stretching exercises, yoga, and Tai Chi exemplify flexibility-boosting activities. Gait training can assist patients in improving their walking posture and gait, ultimately reducing the risk of falls. This can be achieved through practicing proper walking techniques, improving walking speed, and utilizing assistive devices when necessary. Additionally, exercise should be conducted safely, avoiding high-risk activities in unstable environments.

Nutrition

By enhancing nutritional status and providing adequate nutritional support, the risk of falls among hospitalized patients can be mitigated.[71] However, dietary considerations specific to CKD patients must be accounted for. Certain nutrients such as sodium, potassium, and phosphorus may require restriction based on the patient's specific condition.[71] Patients experiencing malnutrition or muscle weakness may necessitate additional protein supplementation. However, it is crucial to supplement protein intake with high-quality protein to prevent proteinuria.[72,73] Patients with osteoporosis may require additional calcium and vitamin D supplementation.[13,74] Meanwhile, maintaining proper hydration is vital to avoid dehydration and fluid overload.[75] For patients unable to meet their nutritional needs orally, nutritional support through intravenous or gastrointestinal routes may be necessary. Therefore, regular nutritional assessments should be conducted to monitor patients' nutritional status and allow for timely adjustments to nutritional interventions.

Equipment

In addition to enhancing the patient's bodily health to prevent falls in hospitalized patients, there exists a range of assistive devices that can be employed for fall prevention. The most common are bedside rails, mobility aids, non-slip mats, non-slip shoes, and non-slip socks. Bed rails play a crucial role in preventing falls, especially during transitions like getting up or changing positions. Presently, most medical beds lack sufficient bed rails or feature inadequately long ones. Future advancements should prioritize user-friendliness and smart functionalities. For instance, incorporating features like voice prompts or lighting cues that activate when the system detects the patient rising can serve as reminders for the patient to prioritize safety.

Moreover, the development of relevant and user-friendly assistive devices is a burgeoning research area. For instance, a fall warning device is an electronic tool that monitors a patient's activity and automatically alarms whenever a patient falls.[76] Furthermore, safety mats with softer surfaces and wearable airbags are utilized to mitigate the impact of a patient's fall and provide additional support.[77–79] These assistive devices and measures should be carefully tailored to the individual patient's needs and circumstances.

Others

The medical and healthcare industries have witnessed significant advancements with the development of data science. Increasingly, big data and artificial intelligence technologies are being utilized in nursing, and these technologies can also play a crucial role in the prevention of patient falls. For example, through the collection and analysis of extensive fall-related data, it becomes possible to construct fall prediction models that aid in assessing a patient's susceptibility to falls.[76] In addition, the integration of virtual reality and augmented reality technologies in the development of training and intervention resources for fall prevention can significantly enhance patients' balance and movement control, ultimately reducing the risk of falling.[80–82] Moreover, in addition to prioritizing fall prevention within healthcare organizations, future research endeavors could concentrate on extending fall prevention initiatives to the community level.[83,84] Implementing measures such as public education and the establishment of community support networks can effectively enhance fall awareness and prevention among older adults residing in the community. Furthermore, aggressive treatment of CKD-related complications, such as arthritis and neurological disorders, can help reduce falls.[6,7]

Limitations

This study presents several limitations. Firstly, the discussion is confined to the common causes of involuntary falls, management strategies, and research trends within the Nephrology Ward. The applicability of these measures to other healthcare departments or home settings warrants further investigation. Secondly, due to the sporadic nature of falls, there is a dearth of pharmacological research. Specifically, quantitative studies focusing on the use of medications to enhance patients' physical and mental well-being for fall prevention are lacking. Consequently, the emphasis in current research lies on fall prevention through nursing interventions and the utilization of equipment to mitigate risks post-fall. Thirdly, CKD patients often present with multiple comorbidities and are on multiple medications, rendering the identification of high-risk factors for falls challenging. Addressing these complexities represents a crucial avenue for future research.

Conclusions

In conclusion, prolonged CKD results in diminished motor function and impaired subjective consciousness by disturbing homeostasis. As a result, patients are prone to involuntary falls under the influence of external and unexpected factors. Presently, the primary approach to prevention revolves around status assessment, science popularization, and nursing management. Patients are also advocated for physical rehabilitation through physical training and nutritional interventions, as well as to utilize assistive devices to support walking. Future research should focus on the development of early warning systems for falls, intelligent assistive tools, personalized prevention programs, and community outreach activities. To summarize, an integrated, multifaceted approach across the healthcare continuum is needed to proactively assess risks, optimize nursing care, encourage patient engagement in recovery, and ultimately create safer hospital environments that minimize preventable harm.

Abbreviations

CRRT, continuous renal replacement therapy; CKD, chronic kidney disease; EPO, erythropoietin; PTH, parathyroid hormone; TSH, thyroid-stimulating hormone.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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