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REVIEW

A Review of Mobile Device Interventions for Continuous Nursing of Patients Undergoing Maintenance Haemodialysis

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Background: Maintenance haemodialysis (MHD) has been one of the most important renal replacement therapies for patients with end-stage renal disease in recent years. Continuous nursing is considered a prerequisite for high-quality healthcare and is crucial for medical staff, patients and their families. Providing continuous nursing services for patients with chronic diseases via mobile medical means can effectively improve the quality of life of medical staff.

Objective: To summarise the application of various mobile device intervention methods for medical patients receiving MHD to provide a reference for the development of mobile health in the continuous nursing of patients undergoing this procedure.

Methods: We conducted a systematic literature search in the following databases: PubMed, Web of Science, Scopus, and CNKI. The literature on the application of various mobile medical methods for nursing patients receiving MHD, both domestic and international, is retrospectively reviewed. The current research results and the existing problems are summarised.

Results: A total of 18 studies were reviewed, which showed that Chinese researchers have preliminarily explored the relevant problems of applying mobile healthcare to the continuous nursing of patients receiving haemodialysis and have achieved some effective applications. Based on the "Internet+" medical concept, providing follow-up, health guidance, psychological counselling and other continuous nursing services for patients with chronic diseases via mobile medical means can effectively improve the work efficiency of medical staff, as well as the self-management ability and compliance of patients.

Conclusion: Mobile health has great potential and prospects in the continuous nursing of patients receiving MHD, For instance, a WeChat-based intervention could improve patients' satisfaction and trust in nurses. But it also requires further research and improvement to ensure its quality and safety.

Keywords: haemodialysis, coagulation during cardiopulmonary bypass, mobile medicine, continuous nursing

Introduction

End-stage renal disease (ESRD) is the terminal stage of various chronic kidney diseases (CKDs), and maintenance haemodialysis (MHD) is one of the most important renal replacement therapies for patients with ESRD.[1] Patient survival rates have improved due to the continuous improvement in haemodialysis technology; however, improving the survival rate and quality of life of patients receiving MHD is still a significant clinical challenge.[2] Due to insufficient knowledge about ESRD and MHD, most patients receiving MHD are incapable of out-of-hospital self-management, which significantly impacts their quality of life.[3] Continuous nursing is considered a prerequisite for high-quality healthcare and is crucial for medical staff, patients and their families.[4] Patients receiving MHD have a high demand for continuous nursing in the form of blood pressure control, arteriovenous fistula maintenance and family support.[5] Traditional continuous nursing predominantly entails communication by telephone and messaging, family visits, emails and

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outpatient reviews. These methods, however, have their shortcomings. For example, telephone follow-ups are not visual, and family visits can be time-consuming and laborious. The needs of patients can no longer be met by continuous nursing.[6]

In recent years, due to the rapid development of mobile networks, the provision of efficient and convenient nursing services for patients through mobile health services has increasingly become an important focus for nursing research.[7] This study summarises research on the application of overseas mobile health in the long-term nursing of patients receiving MHD in China. It aims to provide a reference for the application development and research of mobile health in the long-term nursing of these patients.

We conducted a systematic literature search in the following databases: PubMed, Web of Science, Scopus, and CNKI. We used the following keywords and their combinations: "mobile health", "mobile device", "continuous nursing", "maintenance haemodialysis", and "end-stage renal disease". We included studies that were published in English or Chinese from January 2010 to December 2021, that reported the application of mobile health in continuous nursing of patients receiving maintenance haemodialysis, and that evaluated the outcomes of such interventions. We excluded studies that were not original research, such as reviews, editorials, or case reports, or that did not focus on the target population or intervention. We screened the titles and abstracts of the retrieved studies and assessed the full texts of the eligible studies for inclusion. We summarized the results narratively.

Application of Mobile Health in Continuous Nursing

Overview of Continuous Nursing

"Cohesive nursing" is a new nursing mode that acts as a bridge between inpatient care and overall care at home. It alleviates interruptions in healthcare guidance caused by transferring work areas and serves as a continuous and holistic healthcare method for patients. Continuous nursing also refers to the general extension of care from the hospital to the family environment. Cheng Jing et al[8] proposed the second core element of continuous nursing as being a continuation of patient-targeted health services and time, including the following three elements: (1) the extension of patient data; (2) the continuation of nursing services and (3) the continuation of the therapeutic relationship services of professional medical staff. Continuous nursing planning emphasises the basic mental health needs of patients after discharge. Concurrently, this process provides an organic connection between the planning of hospital nursing and the guidance of visiting nurses, and more attention is paid to the cultivation of patients' physical rehabilitation ability and service quality after discharge. Continuous nursing helps to promote the establishment of a more benign cooperative relationship between medical professionals and patients while also promoting patients' overall health.

Advantages of the Application of Mobile Health in Continuous Nursing

The World Health Organisation defines mobile health as the provision of support for medical and public health practices through mobile devices, such as mobile phones, nursing monitors for patients, personal digital assistants and various wireless intelligent terminal devices.[9] The American Geriatric Society defines continuous nursing as a series of actions designed to ensure the coordination and continuity of services received by patients when they are transferred between different sites or between different levels of health services within the same site.[10] As early as the 1980s, the global nursing academic community, led by China, began paying attention to the use of modern information technology for out-of-hospital–continuous nursing and has continued to carry out relevant research. At present, the service industry using mobile medical resources to provide consultation and healthcare in Western countries has become common, and a relatively comprehensive service model has been developed.[11]

Inspired by the development model of continuous nursing abroad and influenced by a domestic need for improved continuous nursing, China has begun to apply mobile internet technology in this field. In 2018, the National Health Commission proposed in the Guiding Opinions on Promoting the Reform and Development of Nursing Service Industry that China should make full use of the opportunities provided by internet technology to dynamically enhance the construction of nursing information, gradually promote continuous nursing services and incorporate the concept of "Internet+" into the development strategy of nursing health undertakings.[12] With the advent of the Internet+ era, mobile

hospital services have gradually become more widely used in continuous medicine in China, which has greatly expanded the efficacy of medical staff and effectively solved the problem of pressure on hospital resources.[13]

The Effect of Continuous Nursing on Patients Receiving Haemodialysis

Routine care is limited to in-hospital patients only, whereas continuous nursing is an extension of hospital care that addresses the subsequent health problems of some patients and helps to meet their health needs in their daily lives.[14] Luo et al[15] found that patients receiving MHD had a strong demand for continuous care; it is thus suggested that targeted extended nursing services be provided to improve the quality of life of patients receiving haemodialysis.

Many studies indicate that the application effect of continuous nursing among patients receiving haemodialysis is significant. As shown by Xiong et al[16] continuous care programmes, such as education and guidance on accessing vascular care, information about drug use and diet and nutrition care, psychological counselling, emotional support and exercise guidance, can improve the self-management and quality of life of patients receiving haemodialysis. Rahimi et al[17] found that continuous nursing had a positive effect on the anxiety, depression and stress of patients receiving haemodialysis, which is highly practical.

Problems with Long-Term Nursing for Patients Receiving Haemodialysis

Coagulation

Within the process of extracorporeal circulation treatment, haemodialysis is particularly technical. It not only carries great risk but can also result in accidents, such as dialyser and pipeline coagulation.[18]

The condensation of dialysers is a special condition associated with human coagulation. At this point, the colour of the dialyser changes and gradually expands, and finally becomes dark black, and black shadows or purple stripes can be observed inside. If there is a foreign body in the arteriovenous pot, air bubbles will be observable, the water quality will become hard, the pressure in the pipeline will increase and many blood clots will be present when observed closely. In cases such as these, the blood-flow channel will become blocked, and the change in air pressure will push the blood flow back into the pipe. At the arterial end of the dialyser, the transmembrane and intravenous pressures will change during coagulation, and the machine's alarm will sound.[19]

Pipeline coagulation typically occurs in a venous catheter. If a cerebral embolism occurs, the filter set will become blocked, resulting in serious pipeline coagulation and many blood clots, and blood circulation will be compromised. The local voltage will suddenly increase, the current will exceed the specified range, the motor will signal an alarm and then stop working, and the blood pump will cease to function.[20]

The common reasons for blood coagulation in extracorporeal circulation are as follows.

1) Long-term hypercoagulation in patients: in the process of medical treatment, based on the condition of some patients, their blood will remain in a hypercoagulable state for a long time. When this happens, blood clotting can occur during kidney blood washing; this includes patients with hypertension, diabetes, hyperlipidaemia and polycythaemia, as well as patients with rapid weight gain, concurrent infectious diseases or those whose plasma viscosity is very high, leading to blood clotting.[21]

2) Inadequate use of anticoagulants: anticoagulants are an important measure for preventing patients' blood from clotting during fluoroscopy and experiments. The research results presented by Gao Min et al[22] indicated that liver proteinase is generally used for anticoagulation in medical experiments using a dosage of 0.4 mg/kg. However, this dosage should be adjusted according to the specific condition of the patient. If the first dose of anticoagulant is insufficient, the risk of blood coagulation will be higher.

3) Insufficient blood flow volume: insufficient blood flow refers to blood flow lower than 200 mL/min, which is a common clinical complication in patients receiving haemodialysis. Timely and accurate diagnosis is key to ensuring the success of haemodialysis.[23]

4) Pre-rinsing treatment: studies indicate the issue of gas accumulation in the filter as another main cause of blood clotting.[24] When there is no active antifreeze composition in the selected prewash fluid, the unfinished exhaust will lead to a small amount of exhaust gas remaining in the pipeline, causing the contact area between the meridians, the qi and the

blood to gradually increase. In particular, during antifreeze experiments without liver protease, when the blood passes through the dialyser, there is a tendency for a partial attachment phenomenon to occur on the dialysis membrane, which increases the damage caused by blood coagulation and can even lead to the alarm sounding or the immediate stopping of the dialysis machine.

Catheter-Related Bloodstream Infections (CRBSIs)

CRBSIs are a primary concern for patients with indwelling catheters. These infections, often characterized by symptoms like redness, swelling, pain, and systemic issues such as fever and chills, pose a significant risk.[25] Mobile devices can be instrumental in tracking these symptoms, enabling early detection and prompt intervention. The factors affecting CRBSIs, such as the catheter's indwelling position and duration, as well as patient-specific factors like age and conditions like diabetes mellitus, can also be monitored through specialized mobile applications.[26–28]

Malnutrition

Malnutrition, with its prevalence reported as high as 76% in MHD patients, critically impacts their quality of life and long-term prognosis.[29–31] Mobile devices can assist in monitoring dietary intake and nutritional status, ensuring patients receive adequate nutrients. They can also help in tracking complications related to malnutrition, such as increased infection risks and cardiovascular issues.[32]

Dialysis-Related Amyloidosis

This condition, involving the deposition of amyloid material in joints and periarticular tissues, leads to significant discomfort and mobility issues.[33] Mobile health apps could be utilized for regular monitoring of symptoms like carpal tunnel syndrome and joint pain, facilitating early intervention and better management of the condition.

Renal Anemia

Renal anemia, a common complication in CKD, affects various organ functions and exacerbates CKD progression.[34–37] Mobile devices can play a key role in tracking hemoglobin levels, managing erythropoietin administration, and monitoring the patient's overall response to treatment. The multifactorial causes of renal anemia, including reduced erythropoietin production and iron metabolism issues, can be better managed through mobile-based tracking and reminders for medication and dietary adjustments.[38]

Renal Osteodystrophy

The mineral and bone disorders associated with CKD, such as abnormal calcium, phosphorus, and vitamin D metabolism, pose significant health risks.[39] Mobile technology can aid in monitoring these parameters, assisting in the management of bone health. With the increasing incidence of low-turnover bone disease in ESRD patients on MHD, mobile devices can be crucial in tracking symptoms and managing treatments to reduce the risk of cardiovascular events and mortality.[40,41]

Application Type and Content of Mobile Health in the Continuous Nursing of Patients Receiving Maintenance Haemodialysis

Provision of Continuous Nursing for Patients Receiving Maintenance Haemodialysis Through Social Media

"Social media" commonly describes a specialised website or application, such as Facebook, Twitter, Weibo, QQ and WeChat.[42–44] During the process of their condition- receiving treatment, patients will have different information needs, and social media can provide a long-term, real-time and interactive communication platform for them to satisfy these needs and allow them to better adapt to the disease process.[43] A community help for dialysis patients study conducted by Afsar[45] of 134 patients receiving haemodialysis showed that patients with email, Facebook or Twitter accounts led more comfortable lives and had a lower prevalence of depression, while patients who utilised social media as an intervention

also experienced better quality of life and sleep. WeChat has a significant number of users in China and has become a commonly used tool in the country's continuous nursing model due to its convenience and immediacy.[46] Xu Jun et al[47] used WeChat groups to provide access to haemodialysis knowledge, online question-and-answer sessions, dietary guidance and other continuous nursing services for long-term patients receiving haemodialysis, with the results showing that patients' treatment compliance and self-management abilities significantly improved. By establishing a continuous nursing professional team, Qin et al[42] provided continuous nursing services to patients through a haemodialysis WeChat public platform and WeChat groups. The results showed that disease knowledge scores, health behaviour scores and fluid control compliance in the intervention group were significantly higher than in the conventional control group ($P < 0.05$). Wang Jiao et al[48] used WeChat technology to conduct long-term follow-ups for adult patients receiving haemodialysis and implemented daily professional monitoring training, project testing, regular safety training, psychology lectures and other programmes for patients. The results showed that patients' tension and anxiety levels were lowered, and the efficacy of dialysis was also significantly improved.

Provision of Various Types of Continuous Nursing Services for Patients Receiving Maintenance Haemodialysis Based on Mobile Applications

Continuous treatment realised through network media can mainly be administered through conventional modules such as information and video communication and mobile software provided by a network, without a disease-specific operation guidance function. In recent years, mobile medical software applications (APPs) have been developed to set their functional module according to a patient's specific needs and execute additional functions.[49] Bartlett et al[50] tracked the medication status of patients with CKD and regularly guided them in taking medication through a mobile medical APP, thereby greatly improving patients' medication compliance. Hayashi et al[51] developed a dialysis self-management software APP that could evaluate and control patients' weight gain during dialysis intervals and serum potassium and phosphorus content during dialysis, which effectively assisted patients in enhancing their awareness of self-management, thus reducing the incidence of adverse events.

Xu Niobium et al[52] guided the physical activity training of home-based patients receiving dialysis using exercise software called "Dialysis Little Assistant", designed by their medical department. The results showed that, as with the routine physical exercise training method, guiding physical exercise using an APP significantly enhanced the physical well-being of home-based patients receiving dialysis, thereby improving their quality of life. Dong Yongze et al[53] developed a weight management APP to dynamically monitor the weight gain of patients receiving dialysis. The test results showed that weight management using an APP could significantly reduce the rate of weight gain in patients receiving MHD and thus improve the compliance rate of fluid intake.

Network Information Platforms as an Effective Tool for Obtaining Continuous Nursing Services for Patients Receiving Maintenance Haemodialysis

As a new type of medical care intervention, the network health information service platform has been gradually applied to nursing guidance for patients following home visits, including detecting basic life indicators.[54] The American Association of Kidney Patients established the myHealthy electronic health records platform, allowing patients to view their health records at home, receive personalised advice and guidance from doctors, learn about the disease and help them understand test reports.[55] Hernandez et al[56] used a network platform to carry out psychological interventions for patients receiving dialysis with severe long-term depression. The interventions mainly included health behaviour records, online questionnaire tests and education about health mindfulness. The results showed that active psychological intervention based on the network platform was generally effective, and the depression of participants was also improved.

Farragher et al[57] used an internet platform to teach patients receiving MHD how to conduct energy management and reduce unnecessary energy consumption to relieve their fatigue symptoms. Chen Yan et al[58] built a management and follow-up information system for CKD based on mobile health to carry out full and seamless tracking and management consultation for patients from the internal to the external hospital environment. They also developed a mutual network communication platform with medical staff to effectively manage patient problems. Lin Yamei et al[59] uploaded their

professional knowledge of internal fistula maintenance, exercise methods, blood pressure monitoring and drug administration to the mental health teaching platform for patients receiving MHD to study at home and boosted the interactive communication between medical staff and patients using communication software, thereby helping patients receiving MHD to improve their self-management abilities and prevent complications.

In summary, the studies reviewed in this section showed that mobile health interventions can improve the outcomes of patients receiving MHD in various aspects, such as knowledge, self-management, compliance, quality of life, psychological well-being, and dialysis efficacy. The interventions were delivered through different types of mobile devices, such as social media, mobile applications, and network information platforms, and involved different contents, such as information, communication, education, guidance, counselling, monitoring, and feedback. The interventions were tailored to the specific needs and preferences of the patients and were designed to address the problems and complications they faced in long-term nursing. The interventions were also supported by professional and multidisciplinary teams that provided continuous and comprehensive care for the patients. The studies demonstrated the potential and feasibility of mobile health in the continuous nursing of patients receiving MHD, but also highlighted some challenges and limitations, such as the lack of standardisation, the protection of privacy, and the evaluation of effectiveness.

Conclusion and Outlook

Conclusion: Mobile health has great potential and prospects in the continuous nursing of patients receiving MHD, as it can provide convenient and effective ways to address the problems and complications they face and improve their outcomes and quality of life. However, mobile health also requires further research and improvement to ensure its quality and safety, and to overcome the challenges and limitations in its application.

Consent for Publication

All authors final approval of the version to be published.

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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