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A REVIEW ON CLINICAL PATTERNS AND OUTCOMES OF INFECTIONS IN MAINTENENCE HAEMODIALYSIS PATIENTS

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ABSTRACT
For patients on maintenance hemodialysis (MHD), infections pose a serious risk to their quality of life and clinical results. This review aims to present a thorough examination of the clinical trends and infection outcomes in this susceptible group. Patients with MHD are more likely to get infections because of things like comorbid illnesses, weakened immune systems, and frequent vascular access. This review summarizes the most recent research on the epidemiology, risk factors, and kinds of infections that are frequently seen in individuals with mental illness (MHD), including infections linked to vascular access, respiratory infections, and peritonitis. It draws attention to patterns in infection rates, the effects of various dialysis techniques, and the efficiency of various approaches to infection control and prevention. Furthermore, the review addresses how infections affect patient outcomes, such as hospitalization rates, morbidity, and death. Also examined are new developments in infection control techniques and the function of antibiotic stewardship. This review offers important information for healthcare providers to enhance infection management techniques in MHD patients by combining results from current studies and clinical trials. The analysis emphasizes the necessity of ongoing research to create focused therapies that can improve patient outcomes overall and reduce the risk of infection in this high-risk population.

KEYWORDS: Clinical patterns, Outcomes, Infections, Maintenance hemodialysis, Patients.

INTRODUCTION
When the kidneys can no longer effectively filter waste materials and extra fluid from the blood, patients with end-stage renal disease (ESRD) or severe chronic kidney disease (CKD) are treated with hemodialysis (HD), a renal replacement therapy. With HD, the patient's blood is circulated through a dialyzer outside of their body, cleansed, and then put back inside. Usually taking place multiple times a week, these sessions last between three and five hours.

Process of hemodialysis
1. **Vascular access:** HD cannot be treated without a dependable vascular access:
   - An artery and a vein are surgically connected via an arteriovenous (AV) fistula.
   - Arteriovenous (AV) graft: Implantation of a synthetic tube to establish a vein-artery connection.
   - Central venous catheter: A tube that is usually placed temporarily in the chest or neck and inserts into a major vein.
2. **Dialyzer:** The dialyzer, sometimes called a "artificial kidney," is made up of hundreds of microscopic artificial hollow fibers that allow blood to pass through them. Cleansed blood returns to the body as waste materials and extra fluid are eliminated through the fibers.
3. **Dialysate:** A carefully prepared solution that aids in the diffusion process, which removes waste materials from the blood. Within the dialyzer, a semi-permeable membrane is on opposite sides to the dialysate and the patient's blood flow.[1,2,3,4]

Importance of Infections in HD Patients
For patients on maintenance hemodialysis, infections are a serious issue for a number of reasons:
1. **Vascular access:** The risk of infection is increased when vascular access (catheters, grafts, and fistulas) is created and maintained for HD. Particularly with central venous catheters, there is a significant chance of bloodstream infections.
2. **Immunocompromised state:** Patients with end-stage renal disease (ESRD) frequently have damaged immune systems, which increases their susceptibility to infections.
3. **Frequent healthcare exposure:** Extended usage of medical equipment and frequent dialysis center visits raise the risk of nosocomial infections (hospital-acquired infections).

Importance of hemodialysis

1. **Waste removal:** As a result of renal failure, waste materials such as creatinine and urea accumulate in the blood and are eliminated by HD.
2. **Fluid balance:** By eliminating extra fluid, it helps avoid consequences like hypertension and edema.
3. **Electrolyte equilibrium:** HD keeps electrolytes including calcium, sodium, and potassium in equilibrium.
4. **Symptom relief:** HD enhances the patient's quality of life by reducing uremia symptoms as fatigue, nausea, and itching.[5,6]

Epidemiology

Patients on maintenance hemodialysis (HD) are at high risk for infections because of the high incidence and prevalence of complications such as vascular access infections and bloodstream infections (BSIs). Between 0.5 and 3.5 episodes occur in every 100 patient-months among HD patients, and between 10 and 30 percent of patients have at least one BSI in a given year. The kind of vascular access has a substantial impact on the risk of infection. Compared to arteriovenous (AV) fistulas and grafts, central venous catheters (CVCs) have the greatest infection rates, with up to 8.7 episodes per 100 patient-months. Patients with HD have impaired immune systems as a result of uremia, other medical disorders, and frequent hospital visits, which makes them more vulnerable to infections. Staphylococcus aureus (including MRSA), coagulase-negative staphylococci, Escherichia coli, Klebsiella species, and Pseudomonas aeruginosa are common pathogens. Candida species are fungus that can cause serious illness, but they are less common. HD patients who have infections are more likely to experience higher rates of morbidity, longer hospital stays, greater healthcare expenses, and a significant decline in mortality and quality of life.[7,8]

Types of infections

Because maintenance hemodialysis (HD) patients are more susceptible to infections from both the dialysis technique and the underlying kidney disease, infections are a major issue. The following are the main categories of infections that these patients have:

1. **Access-Related infections**
   - **Central Venous Catheter (CVC)-Related Infections:** CVCs are initially used for vascular access by many HD patients. Bacteria may enter through these catheters and cause infections such tunnel infections and catheter-related bloodstream infections (CRBSIs).
   - **Arteriovenous Fistula (AVF) and Graft Infections:** AVFs and grafts are two forms of alternate access. These locations are susceptible to infection, though less so than CVCs. They frequently show up as bacteremia or localized infections.
2. **Systemic infections**
   - **Sepsis:** Patients with HD are more likely to experience sepsis, which is a result of an infection-related systemic inflammatory response syndrome (SIRS). Pneumonia, soft tissue infections, UTIs, and access-related illnesses can all result in sepsis.
   - **Urinary Tract Infections (UTIs):** Frequent catheterization, urinary tract instrumentation, and underlying urologic problems make UTIs common in HD patients. If left untreated, they can result in sepsis and bacteremia.
   - **Respiratory Infections:** When it comes to senior HD patients who also have concomitant conditions like chronic obstructive pulmonary disease (COPD), pneumonia and bronchitis are serious issues.
   - **Soft Tissue Infections:** These include cellulitis and abscesses, which are frequently brought on by invasive treatments or breaches in the skin's integrity.
3. **Dialysis-Associated infections**
   - **Endotoxin Release:** Endotoxins, which are produced from bacterial cell walls during dialysis, have the potential to cause inflammatory reactions.
   - **Membrane-Associated infections:** Even with routine disinfection procedures, biofilm growth on dialyzer membranes might lead to recurring infections.
   - **Waterborne infections:** Pathogens can enter contaminated water used to prepare dialysate, leading to systemic infections.
4. **Other infections**
   - **Gastrointestinal infections:** Because of their weakened immune systems and frequent hospital stays, HD patients may be more vulnerable to gastrointestinal infections.
   - **Skin and Soft tissue infections:** These infections are particularly common in persons with diabetes or weakened immune systems.
   - **Vascular Access-Related Infections:** These comprise infections involving grafts used for vascular access or the AVF.

A multidisciplinary strategy combining nephrologists, infectious disease specialists, and dialysis professionals is necessary for the management of infections in HD patients. In order to lower the morbidity and mortality linked to infections in this susceptible population, preventive interventions like stringent aseptic methods during catheter insertion, routine surveillance cultures, antibiotic prophylaxis, and patient education on infection prevention are essential.[9,10,11,12,13]

Microbiology of infections

The microbiology of infections in dialysis patients can vary widely based on the type of infection and the patient's clinical setting. Here's a general overview.

1. **Catheter-related bloodstream infections (CRBSI)**
   - **Common pathogens:** Staphylococcus aureus (including methicillin-resistant strains, MRSA), coagulase-negative staphylococci (e.g., Staphylococcus epidermidis), Enterococcus spp., Gram-negative bacteria (e.g., Escherichia coli, Pseudomonas aeruginosa).
   - **Risk Factors:** Skin flora contamination during catheter insertion, biofilm formation on catheter surfaces.

2. **Arteriovenous fistula (AVF) infections**
   - **Common pathogens:** Similar to CRBSI, including skin flora and potentially more virulent organisms depending on the severity.
   - **Risk factors:** Poor hygiene, inadequate vascular access care, immunosuppression.

3. **Peritonitis (In peritoneal dialysis)**
   - **Common pathogens:** Coagulase-negative staphylococci, Staphylococcus aureus, Streptococcus spp., Enterococcus spp., Gram-negative bacteria (e.g., Escherichia coli, Klebsiella pneumoniae).
   - **Risk factors:** Breaks in sterile technique during dialysate exchanges, exit site infections, translocation of gut flora.

4. **Respiratory tract infections (Including pneumonia)**
   - **Common pathogens:** Streptococcus pneumoniae, Haemophilus influenzae, Staphylococcus aureus, Gram-negative bacteria (e.g., Klebsiella pneumoniae, Pseudomonas aeruginosa), respiratory viruses (e.g., influenza viruses, respiratory syncytial virus).
   - **Risk factors:** Aspiration, immunosuppression, exposure in healthcare settings.

5. **Urinary tract infections (UTI)**
   - **Common pathogens:** Escherichia coli (most common), Klebsiella pneumoniae, Proteus mirabilis, Enterococcus spp.
   - **Risk factors:** Indwelling urinary catheters, urinary tract abnormalities, frequent instrumentation.

6. **Skin and Soft tissue infections**
   - **Common pathogens:** Staphylococcus aureus (including MRSA), Streptococcus pyogenes, Gram-negative bacteria (e.g., Pseudomonas aeruginosa).
   - **Risk factors:** Breaks in skin integrity, vascular access procedures, compromised immunity.

7. **Gastrointestinal infections**
   - **Common pathogens:** Norovirus, rotavirus, Escherichia coli (including enterotoxigenic strains), Clostridium difficile.
   - **Risk factors:** Exposure to contaminated food or water, frequent hospitalization.

8. **Bloodstream infections (Sepsis)**
   - **Common pathogens:** Similar to CRBSI and other primary infections, often polymicrobial in nature.
   - **Risk factors:** Invasive procedures, immunosuppression, prolonged hospital stays.[14,15,16,17,18]

Antibiotic resistance patterns

Antibiotic resistance patterns and emerging pathogens present significant challenges in the management of infections in dialysis patients. Here's an overview:

Antibiotic resistance patterns

1. **Methicillin-Resistant staphylococcus aureus (MRSA)**
   - Common in catheter-related bloodstream infections (CRBSI), skin and soft tissue infections.
   - Resistance Mechanism: Production of penicillin-binding protein (PBP2a) that confers resistance to β-lactam antibiotics.

2. **Vancomycin-Resistant Enterococcus (VRE)**
   - Seen in bloodstream infections, particularly in patients with prolonged hospitalizations.
   - Resistance Mechanism: Altered peptidoglycan synthesis preventing vancomycin binding.

3. **Extended-Spectrum β-Lactamase (ESBL)-Producing Gram-Negative Bacteria**
   - Including Escherichia coli, Klebsiella pneumoniae.
   - Resistance Mechanism: Production of enzymes that hydrolyze extended-spectrum β-lactam antibiotics, limiting treatment options.

4. **Carbapenem-Resistant Enterobacterales (CRE)**
   - Increasingly reported, posing significant challenges due to limited treatment options.
   - Resistance Mechanism: Production of carbapenemases that hydrolyze carbapenem antibiotics.

5. **Multidrug-Resistant Pseudomonas aeruginosa**
   - Common in healthcare-associated infections, including pneumonia and bloodstream infections.
   - Resistance Mechanism: Efflux pumps, decreased outer membrane permeability, production of β-lactamases.[19,20]

Clinical presentations

Infection type	Clinical presentation
Access Site Infections	- Localized pain, swelling, or erythema at catheter or AVF site
	- Purulent discharge or drainage

Catheter-Related Bloodstream Infections (CRBSI)	- Fever, chills
	- Hypotension, altered mental status
Peritonitis (in peritoneal dialysis patients)	- Abdominal pain, cloudy peritoneal fluid
	- Fever, nausea, vomiting
Respiratory Tract Infections	- Cough, dyspnea
	- Sputum production, chest pain
Urinary Tract Infections (UTI)	- Dysuria, frequency
	- Hematuria, cloudy or foul-smelling urine
Skin and Soft Tissue Infections	- Localized warmth, erythema, swelling
	- Purulent drainage, pain on palpation
Gastrointestinal Infections	- Abdominal pain, diarrhea
	- Nausea, vomiting, dehydration
Bloodstream Infections (Sepsis)	- Fever, hypotension[21,22]

Diagnosis

Infection type	Diagnostic approach
Catheter-Related Bloodstream Infections (CRBSI)	Blood cultures (from catheter and peripheral vein), catheter tip culture, imaging if complications suspected
Arteriovenous Fistula (AVF) Infections	Clinical examination, imaging (ultrasound), culture of drainage if present
Peritonitis (in Peritoneal Dialysis Patients)	Peritoneal fluid analysis (cell count, culture), assessment of dialysate effluent
Respiratory Tract Infections	Chest X-ray, sputum culture, respiratory viral panel if indicated
Urinary Tract Infections (UTI)	Urinalysis, urine culture (consider catheterized specimen), imaging if complications suspected
Skin and Soft Tissue Infections	Clinical examination, wound culture if indicated, imaging for deeper infections
Bloodstream Infections (Sepsis)	Blood cultures (multiple sets), imaging (if source unclear), echocardiography[23,24]

Treatment

Treatment of infections in maintenance hemodialysis (HD) patients is complex and requires careful consideration due to the unique challenges posed by their condition. These patients have compromised immune systems and frequent vascular access, which increase their susceptibility to infections. Here's a detailed explanation of the treatment approaches for different types of infections in this patient population:

1. Vascular Access-Related infections

a. Arteriovenous Fistula (AVF) Infections

- **Antibiotics:** Empirical broad-spectrum antibiotics (e.g., vancomycin or cefazolin) until culture results are available.
- **Surgical intervention:** Debridement or fistula revision may be necessary for severe infections.

b. Arteriovenous Graft (AVG) Infections

- **Antibiotics:** Empirical therapy followed by targeted antibiotics based on culture results.
- **Surgical intervention:** Removal or revision of the graft if the infection is severe or persistent.

c. Central Venous Catheter (CVC) Infections

- **Antibiotics:** Empirical antibiotics (e.g., vancomycin and cefepime) initially, adjusted based on culture results.
- **Catheter management:** Catheter removal and replacement if the infection is severe or unresponsive to antibiotics. Antibiotic lock therapy can be used as an adjunct.

2. Bloodstream infections (BSIs)

- **Antibiotics:** Immediate initiation of broad-spectrum antibiotics (e.g., vancomycin plus a gram-negative coverage agent like cefepime) until the causative organism is identified.
- **Supportive care:** Hemodynamic support, fluids, and other supportive measures as needed.

3. Respiratory infections

- **Antibiotics:** Empirical therapy with broad-spectrum antibiotics (e.g., levofloxacin, piperacillin-tazobactam) based on the severity of the infection and local resistance patterns, followed by targeted therapy based on culture results.
- **Supportive care:** Oxygen therapy, bronchodilators, and mechanical ventilation if necessary.

4. Urinary Tract Infections (UTIs)

- **Antibiotics:** Empirical broad-spectrum antibiotics (e.g., ciprofloxacin or trimethoprim-sulfamethoxazole) initially, adjusted based on urine culture results.

- **Prevention:** Regular monitoring and catheter care to prevent recurrent infections.

5. Skin and Soft tissue infections

- **Antibiotics:** Empirical coverage with antibiotics like vancomycin or linezolid for MRSA coverage, followed by targeted therapy based on culture results.
- **Surgical intervention:** Incision and drainage of abscesses if present.

6. Gastrointestinal infections

- **Antibiotics:** Oral vancomycin or fidaxomicin for mild to severe CDI, with intravenous metronidazole as an adjunct in severe cases.
- **Supportive care:** Fluid and electrolyte management, probiotics.

7. Fungal infections

- **Antifungals:** Empirical therapy with echinocandins (e.g., caspofungin) or fluconazole, followed by targeted therapy based on culture results and antifungal susceptibility.
- **Catheter management:** Removal of any indwelling catheters if involved.

General principles

- **Infection control:** Adherence to strict aseptic procedures when manipulating catheters and doing dialysis.
- **Antibiotic stewardship:** Preventing antibiotic resistance by avoiding antibiotic usage.
- **Regular monitoring:** Consistent surveillance cultures and infection sign observation.
- **Patient education:** Teaching patients about infection warning signs and the value of good hygiene.[25,26,27]

Outcomes of infections in maintenance hemodialysis

Patients receiving maintenance hemodialysis are susceptible to a number of negative consequences from infections, which can affect their general health, dialysis therapy, and medical expenses:

1. Morbidity

Hemodialysis patients' morbidity is greatly increased by infections. Among the ways that infections affect morbidity are:

- **Acute complications:** These can include sepsis and other systemic infections as well as localized infections at the vascular access site. If localized infections are not treated right away, they might worsen and result in cellulitis, abscesses, or osteomyelitis.
- **Chronic complications:** Recurrent or persistent infections can result in long-term health problems such endocarditis, an inflammation of the heart's inner layer that includes the heart valves.
- **Exacerbation of comorbidities**: Pre-existing illnesses like diabetes, cardiovascular disease, or chronic respiratory disorders can be made worse by infections, which can lower general health status.

2. Mortality

Among patients on maintenance hemodialysis, infections are the primary cause of death. There are multiple variables that lead to the elevated death rate:

- **Sepsis:** This potentially fatal reaction to an infection can result in organ failure and demise. Patients receiving hemodialysis are especially susceptible to sepsis because of the frequent modification of their vascular access.
- **Severe respiratory infections:** Pneumonia, for example, can be deadly, especially in people with weakened immune systems and underlying lung disorders.
- **Catheter-Related infections:** Because bacteria spread through the circulation so quickly, central venous catheters (CVCs) are a common source of bloodstream infections, which have a high fatality rate.

3. Hospitalizations

Hospital admission is frequently required due to infections, which has various consequences:

- **Frequent admissions**: Patients on hemodialysis who have infections often need to be admitted as patients in order to get intense monitoring, surgery, and intravenous antibiotics.
- **Longer hospital stays:** Infections can cause extended hospital stays since they necessitate close observation and intensive care, especially in situations as serious as sepsis or endocarditis.
- **Rehospitalizations:** Rehospitalization is frequently necessary as a result of recurring illnesses or complications following an initial infection.

4. Impact on dialysis access

Hemodialysis requires vascular access, and infections have a major influence on this factor:

- **Access site infections:** Infections can impair the vascular access's functionality, resulting in thrombosis, stenosis, or the access site's total loss.
- **Need for new access:** Infected access sites may need to be surgically removed and replaced, necessitating the implantation of a new catheter or the creation of new arteriovenous fistulas or grafts.
- **Reduced dialysis efficiency:** Inadequate dialysis sessions can be caused by compromised access, which can have an impact on the patient's general health and wellbeing.

5. Economic burden

Infections among hemodialysis patients have a significant financial impact:

- **Treatment costs:** Antibiotics, surgeries, and hospital stays are all part of the expense of treating infections. These expenses may add up, particularly if there are recurring infections or other issues.

- **Indirect costs:** Long-term impairment brought on by serious infections, as well as lost productivity at work for patients and caregivers, are examples of indirect costs.

6. Quality of life

Hemodialysis patients' quality of life is adversely affected by infections:

- **Physical health:** Recurrent infections can cause diminished mobility, excruciating pain, and physical debilitation.
- **Mental Health:** Frequently occurring infections, hospital stays, and the possibility of losing access to dialysis can all cause stress and anxiety that can negatively impact mental health.
- **Social Impact:** Patients who have frequent medical procedures and hospital stays may experience social dislocation and a reduction in their engagement in enjoyable activities as a result of these disruptions to their daily schedules and social lives.

7. **Prevention and Management strategies**

Several tactics are used to lessen the negative effects of infections in hemodialysis patients:

- **Aseptic technique:** When inserting and maintaining vascular access, strict attention to aseptic techniques is essential.
- **Antibiotic prophylaxis:** Preventive use of antibiotics can lower the occurrence of infections in high-risk individuals or circumstances.
- **Vaccination:** Certain illnesses can be avoided by making sure patients obtain the advised immunizations (such as the pneumococcal and influenza vaccines).
- **Patient education:** Giving patients knowledge about good hygiene habits and early infection indicators gives them the power to seek medical attention as soon as possible.
- **Regular monitoring:** It's critical to regularly check vascular access sites for indications of infection and to treat any problems right away.[28,29,30,31]

Future directions

Because maintenance hemodialysis (HD) patients encounter particular obstacles, infection management and treatment is an important area of healthcare. Individuals on maintenance hemodialysis are more vulnerable to infections because of things like frequent vascular access, weakened immune systems, and coexisting medical disorders:

1. Improved vascular access solutions

- **Enhanced catheter Materials and Designs:** Investigation into antimicrobial-impregnated catheters and better catheter cuff designs, as well as materials with antimicrobial qualities and designs that reduce infection risks.
- **Biofilm prevention:** The creation of tactics, such as antimicrobial coatings and innovative catheter designs, to stop biofilm formation on catheters.
- **Alternative access methods:** Investigating less invasive techniques to increase the lifespan of grafts and arteriovenous fistulas (AVF).

2. Antimicrobial stewardship

- **Tailored antibiotic therapy:** Using more exact techniques to identify the best antibiotics depending on the flora and resistance patterns of each patient.
- **Guideline development:** Keeping clinical recommendations up to date and improving them will help avoid antibiotic overuse and lower the likelihood of antibiotic resistance.
- **Pharmacokinetics and Pharmacodynamics:** A deeper comprehension of the impact of dialysis on medication metabolism and the optimization of dosage schedules for patients with HD.[32,33]

3. Infection Surveillance and Monitoring

- **Advanced diagnostic tools:** Quick identification of pathogens and their resistance profiles through the use of rapid molecular diagnostic assays, which enables more focused and expedient treatment.
- **Continuous monitoring technologies:** Wearable sensors and smart gadgets are integrated with real-time monitoring systems for the early detection of illnesses.

4. Vaccination and Preventive measures

- **Enhanced vaccination protocols:** To protect HD patients from diseases such as pneumococcal illness, hepatitis B, and influenza, specialized immunization regimens and recommendations have been developed.
- **Infection control practices:** Better hand hygiene guidelines and environmental disinfection techniques are among the improvements made to infection control procedures in dialysis facilities.

5. Personalized medicine

- **Genomic approaches:** These methods provide individualized treatment plans by using genetic data to predict an individual's vulnerability to infections and reaction to therapy.
- **Patient-Specific risk profiles:** Creating risk assessment instruments that customize prevention and treatment plans by taking into account the unique traits, comorbidities, and infection history of each patient.

6. Education and Training

- **Healthcare professional training:** Constant education about the most recent treatment guidelines and infection control procedures for healthcare providers.
- **Patient education:** Educating patients better about preventing infections, identifying symptoms, and knowing when to get help.

7. Innovative therapies

- **Adjunctive therapies:** Investigating the application of probiotics or immunomodulators as adjuvant therapy to enhance the management of infections and enhance overall patient outcomes.
- **Gene Editing and Cell therapy:** Researching cutting edge treatment approaches, such as gene editing technology, to strengthen immune responses or correct immune system defects..

8. Collaborative care models

- **Integrated care teams:** Providing comprehensive infection management by encouraging interdisciplinary care models incorporating pharmacists, infectious disease specialists, nephrologists, and other medical professionals.
- **Patient-Centered care:** Prioritizing patient participation and self-management techniques to enhance compliance with treatment plans and infection prevention guidelines.[34,35]

CONCLUSION

Patients on maintenance hemodialysis (MHD) face a serious difficulty in managing infections, which has a substantial impact on their quality of life and clinical results. This study focuses on the intricate interactions between a number of variables, such as the vascular access type, the existence of comorbidities, and the innate immune dysfunction linked to chronic renal disease, that all contribute to the high prevalence of infections in this population.

The analysis emphasizes that although some infection rates have decreased as a result of advancements in dialysis technology and infection control procedures, significant variability still exists among various patient demographics and settings. Strategies to improve access site care and put preventive measures in place are essential since vascular access-related infections are still a major concern. Targeted interventions are necessary to address persistent issues such as pneumonia and respiratory infections.

All things considered, the effects of infections on patient outcomes—such as elevated rates of hospitalization, morbidity, and mortality—require a multimodal approach to care. The enhancement of infection surveillance, the optimization of antibiotic stewardship, and the customization of infection prevention tactics ought to be prioritized. To better understand the underlying processes of infections in individuals with MHD and to create novel strategies to lower their frequency and enhance patient outcomes, further study is necessary. Healthcare practitioners can improve infection management practices and eventually improve the health and quality of life of patients with maintenance hemodialysis (MHD) by incorporating the results of current studies into their clinical practice.

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