

PRINCIPLES OF OPERATION OF DIALYSIS DEVICES TODAY AND THEIR FURTHER IMPROVEMENT

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Abstract:

This article reviews the principles of dialysis and explores ways to enhance its effectiveness. Dialysis is a process that assists patients with kidney failure and is performed using an artificial kidney machine. The article provides detailed information about the key components of hemodialysis, including blood vessels, dialyzers, and dialysis solutions. It also examines advanced technologies, new dialysis solutions, innovative dialyzers, and portable home systems designed to improve the efficiency of dialysis machines and enhance patient convenience. Additionally, the article discusses potential improvements in dialysis technologies, focusing on the role of biomaterials and gene therapy. This study aims to identify new opportunities to increase the effectiveness of dialysis treatment and improve the quality of life for patients.

Keywords: Dialyzer, component, portable, gene therapy, biomaterials.

Introduction

Introduction: Dialysis is a medical procedure that assists patients with partial or complete loss of kidney function, using an artificial kidney machine. This method helps remove excess fluid and toxins from the body, while also balancing electrolytes and acids. There are two main types of dialysis: hemodialysis and peritoneal dialysis. Hemodialysis uses an artificial kidney, whereas peritoneal dialysis relies on the patient's own peritoneal membrane as a filter.

Dialysis technology was developed in the mid-20th century. The first dialysis machine was created in 1943 by Dutch doctor Willem Kolff. He developed the first dialyzer, which was originally called an "artificial kidney." Following the success of this prototype, dialysis technology gradually advanced. In 1945, Kolff's dialysis machine began to be widely used, and by the 1960s, the method had become widespread in medicine. Thanks to advancements in hemodialysis technology, many patients' lives were saved during this period.

Dialysis machines operate in two main ways: hemodialysis and peritoneal dialysis. Both methods help remove toxins and excess water from the body, but they are based on different technological principles.

Hemodialysis

Concept: In hemodialysis, blood is directed into a dialysis machine, where it passes through a special membrane called a "dialyzer." This membrane has microscopic openings on its inner surface, allowing toxins and waste products to be removed from the blood while retaining essential components.

Process: During hemodialysis, blood undergoes several stages, passes through the membrane, and is then returned to the body. This process typically takes 3 to 5 hours and is performed three times a week.

Dialyzers are the most crucial components of hemodialysis. They function as an artificial kidney, where blood flows through the dialyzer, and toxins are removed. Dialyzers are equipped with high-performance membranes, the pores of which are specifically sized and hardened to allow only necessary substances to pass through. Materials such as polysulfone, polyamide, and polyethylene are commonly used in the production of dialyzers because of their high biocompatibility and ability to reduce allergic reactions.

Dialysis Fluids are used to maintain an optimal balance in the patient's body. They contain essential ions such as sodium, calcium, potassium, bicarbonate, and other important components. The composition of the dialysis fluid directly impacts the success of the dialysis process.

- **Bicarbonate Dialysis Fluids:** Bicarbonate systems help reduce excess acidity in the body and assist in maintaining proper pH levels.
- **NaCl (Sodium Chloride):** Sodium ions are used in dialysis to manage water and maintain fluid balance in the body.

1. Peritoneal Dialysis

Definition: Peritoneal dialysis uses the peritoneum, a special natural lining that covers the intestines and other internal organs, to filter waste products and excess fluid from the body. Dialysis fluid is introduced into the peritoneal cavity to facilitate this process.

Procedure: Dialysis fluid is injected into the peritoneal cavity, where it remains for several hours. Afterward, the fluid is drained out and replaced with fresh fluid.

Advantages: One of the main advantages of peritoneal dialysis is that it can be performed at home or in a convenient location, enhancing the patient's quality of life.

Improvement of Dialysis Machines

Today, dialysis technology has become more efficient and convenient, with devices undergoing numerous innovations and improvements:

Dialyzer Innovations: Modern dialyzers are more biocompatible, meaning they cause fewer reactions with the body, thus reducing the risk of infection and thrombosis. New materials such as polymethylmethacrylate (PMMA) and polysulfone-based dialyzers are known for their high filtration efficiency.

Automated Systems Automated hemodialysis systems, such as "Home GD" (home hemodialysis), allow patients to perform dialysis at home. These systems are supervised by a doctor and monitored remotely through specialized phones and computers. Automated dialysis machines, including those

used for peritoneal dialysis, automatically exchange fluids and carry out the process without the need for patient intervention.

New Methods and Genetic Research

Advances in genetic research and molecular biology are paving the way for new approaches in dialysis technology. These include the development of artificial instructions, new biochips, and nanomaterials to enhance the efficiency of dialysis machines. Efforts to create artificial kidneys have shown promising results. Although some researchers have successfully developed artificial kidneys, this technology has not yet reached widespread use.

PORTABLE DIALYSIS SYSTEMS

Portable and compact dialysis machines, such as the Wearable Artificial Kidney (WAK), enable patients to receive continuous dialysis in a convenient location. These systems offer patients greater independence and added convenience in managing their condition.

There are several promising prospects for further improving dialysis machines:

- **Nanotechnologies:** The use of nanomaterials and nanoprobes in dialysis offers highly efficient filtration, allowing for the purification of even smaller substances.
- **Artificial Kidneys:** The development of artificial kidneys and organ replacement implants aims to enhance the human body's functionality. This new technology could potentially reduce the need for dialysis.

Gene Therapy: The development of gene therapy for kidney failure holds the potential to replace dialysis. This method works by helping to regenerate the kidney.

The following suggestions and new technologies are being explored to improve the efficiency of the hemodialysis process:

- **Dialyzer Improvements:** New technologies are enhancing the efficiency of dialyzers. Through the use of nanotechnology, modern dialyzers can remove toxins more quickly and effectively manage unnecessary fluids in the body.
- **Automated Systems:** Automated hemodialysis systems offer greater convenience for patients. For example, these systems allow patients to be monitored remotely in their own homes or private rooms, making dialysis more comfortable and accessible.

There are also risks involved in the hemodialysis process, which are outlined below:

- **Risk of Infection:** Hemodialysis carries a risk of infection, particularly through the transmission of blood products. Therefore, maintaining and verifying sterility throughout the process is crucial.
- **Thrombosis:** Poor blood flow and fluid exchange during dialysis can increase the risk of thrombosis. To mitigate this risk, dialyzers and blood lines are regularly cleaned.
- **New Technologies:** Emerging technologies, such as synthetic membranes and methods like electrodialysis, are being used to remove harmful substances more quickly and effectively.

CONCLUSION

Hemodialysis remains a vital and life-saving procedure for patients with kidney failure. This article has provided an overview of the fundamental principles of hemodialysis, its mechanism of action, the importance of dialyzers and dialysis fluids, and the introduction of new technologies. The scientific community is actively developing innovative approaches to improve the efficiency of hemodialysis, enhance patient convenience, and make the process safer.

There are significant opportunities to further improve hemodialysis by incorporating automated systems, portable dialysis devices, and advanced biomaterials. Additionally, cutting-edge technologies like gene therapy and cell regeneration have the potential to greatly influence the future of dialysis. The ongoing renewal of dialysis technologies, enhancements in hemodialysis devices, and the introduction of new treatment methods are creating new possibilities for treating kidney diseases.

At the same time, the focus remains on improving patients' quality of life, fostering greater independence, and ensuring effective treatment. In summary, the development of hemodialysis technologies will lead to anticipated advancements that not only improve medical procedures but also ensure a long, high-quality life for patients.

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