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Review Article

Strategies for Reducing Water Consumption in Hemodialysis Therapy; Rapid Review

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Abstract

Arid and semi-arid regions are increasingly facing a major water shortage problem. As the population increases in these regions, water is becoming more and more precious with very limited resources in Near East and North Africa region (NENA). Hemodialysis is a treatment with a high economic and ecological impact, particularly in terms of water consumption. This article aims to define water consumption patterns in hemodialysis centers and to explore strategies from the literature for reducing water consumption in hemodialysis therapy. Economical management of waste water is based on the rule of 3Rs:

A. Reduce the use of water by delaying the need for hemodialysis through education, reducing use in water purification, reducing dialysate flow and optimizing reverse osmosis performance.

B. Reuse dialysate effluent.

C. Recycle dialysis effluent for agriculture and other use. Water conservation should be integrated into routine hemodialysis practice.

BACKGROUND

Water is becoming an increasingly scarce natural resource, and drinking water is inaccurately viewed as an inexhaustible supply [1]. Extreme weather circumstances, in fact, contribute to making water scarcer, more unpredictable, and more polluted. These impacts threaten sustainable development, biodiversity, and people's access to water, in addition to sanitation throughout the water cycle [2]. There is a substantial issue of insufficient water supply in arid and semi-arid areas. As water is becoming increasingly scarce in certain areas, judicious use is essential in Near East and North Africa region (NENA). Hemodialysis is used to treat 90% of patients with chronic kidney disease worldwide [3,4]. Globally, chronic kidney disease is increasing; approximately 3.4 million individuals are being treated with hemodialysis today [5]. Hemodialysis is a therapeutic approach with significant economic and environmental ramifications, particularly concerning water utilization. The attainment of top-notch ultrapure water is a key aspect. The formulation of dialysate, which is employed to eliminate toxins from the patient's bloodstream, necessitates the release of enormous volumes of saline-rich water directly into the drainage system [6,7]. The annual worldwide use of water for hemodialysis is about 265 million cubic meters based on 4-hour treatments three times weekly for 3.4 million patients. Shockingly, this scenario implies the eventual depletion of this resource. Consequently, there is an urgent need to reduce water consumption, increase its use, and prevent waste. Thus, it is essential to think seriously about the optimal management of this resource in order to mitigate the environmental impact of our facilities [8,9]. This review aims to figure out current patterns in water consumption in dialysis centers and to investigate proposed approaches from the research's literature aimed at reducing water consumption during hemodialysis treatment.

WATER CONSUMPTION PATTERNS IN HEMODIALYSIS CENTERS

Purified water is required for hemodialysis fluid preparation. Water preparation includes filtration, ion exchange, and Reverse Osmosis (RO) (Figure 1). Under the influence of hydrostatic pressure, water passes through semi-permeable ion-exclusion membranes in order to separate the solutes (dissolved solutes and insoluble impurities) from the solvent, i.e., water. The filtered solutes remain in the rejected water. The fraction of the rejection

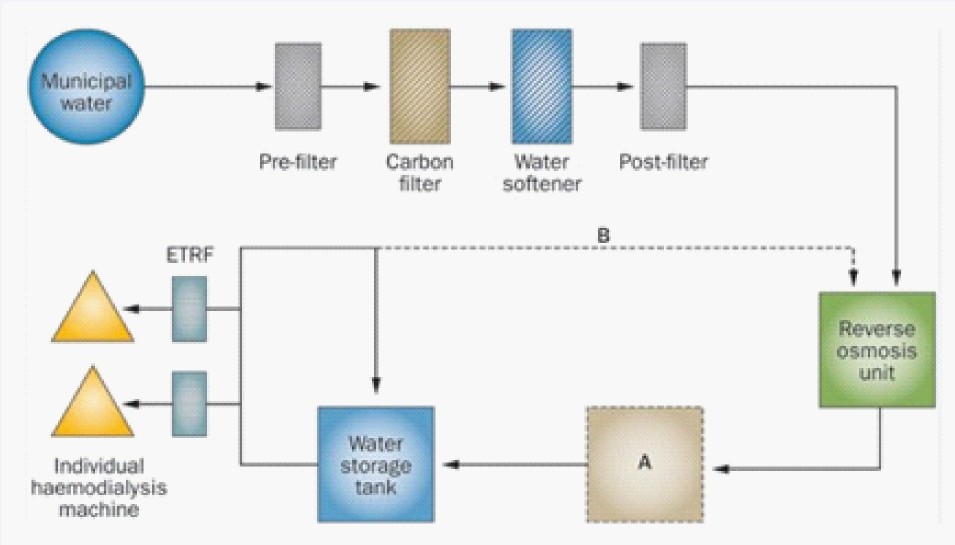

Figure 1 Typical water purification system for a hemodialysis system [12].

volume that influences the effectiveness of RO systems can be low, rejecting up to 75% of the incoming water volume and providing an efficiency as low as 25% [10]. As a result, it can be estimated that with a dialysate flow rate of 500 ml/min for 4 hours, not only 120 liters of water are needed for the dialysis fluid, but up to 480 liters of water, considering the excluded water. Additional water is consumed during the treatment and disinfection cycles in addition to the water required for the treatment itself. This illustrates the degree of water-saving potential offered by the implementation of efficient RO systems in dialysis centers [11].

REDUCE, REUSE AND RECYCLE WASTEWATER IN HEMODIALYSIS

Strategies to Reduce Water Consumption in Hemodialysis

The most effective strategy for reducing water consumption by hemodialysis is to reduce the need for it. In addition, delaying the commencement of dialysis is a way to save water, meanwhile additionally enhancing quality of life [13,14]. Remarkably, modern systems may achieve water efficiency of up to 80% with Reverse Osmosis (RO). Even though water might be saved by reducing dialysate flow, it should not be done at the expense of dialysis adequacy [15,16]. Furthermore, modern hemodialysis machines are outfitted with modules that automatically adjust the dialysis fluid flow rate to the patient's blood flow and diminish dialysis usage during preparation and after reinfusion. Smart utilization of the available alternatives provided by manufacturers enables the conservation of excess acid concentrations and water [17]. A Colombian team, on the other hand, investigated the long-term effects and successfully established that reducing the dialysate flow from 500 to 400mL/min not only had no influence on clinical parameters and Kt/V, but also had no effect on death rates [18]. It is worth noting that when the dialysate flow is synchronized with the present blood flow using a ratio such as 1.2:1, any decrease in blood flow during internal testing, for instance, would consequently modify the dialysate flow. This feature, known as Auto Flow, is available on both the 5008 CorDiax and the 6008 CAREsystem. It may be adjusted to a range of 1:1 to 1.5:1, depending on the clinical needs of each patient [15].

This feature has been studied in numerous investigations to determine the reduction in dialysate consumption in proportion to the achieved dialysis dose. When used in the online hemodiafiltration (HDF) mode, the Auto Flow function reduced dialysis fluid consumption by 8%, accounting for about 16% of the total volume used as substitute fluid. The volume of water generated can be increased by using hydraulic systems or by altering the conductivity of the product water. Another study suggested direct preparation of dialysate from tap water using osmotic dilution [19]. This process exhibited stability and high efficiency in hemodialysis, demonstrating the potential to curtail the need for purified water. The latest generation water treatment systems decrease the proportion of rejected water allowing some of it to be repurposed. Reducing the dialysate flow in standard hemodialysis reduces water consumption but risks a negative impact on dialysis efficiency. However, in cases where online hemodiafiltration (HDF) is prescribed, a reduction in dialysate flow might be employed to diminish water requirements while upholding the effectiveness of the dialysis process [20].

Strategies to Reuse Water Wastewater

The rejected water is frequently emptied immediately and wasted. However, some units have reported innovative uses for this rejected water, such as toilet flushing, which saves water at other points along the system [21]. Water rejection due to

Reverse Osmosis (RO) process provides an opportunity for various applications. It's significant to note that water discharged from the RO system does not come into contact with patients' blood, thus posing no risk of infection. Because treated water is enriched with salts, it adheres to the quality standards for potable water. While a meticulous assessment of wastewater is required to strategically plan its reuse, there are no physical constraints to repurposing RO rejection water. For instance, it could be used for various in-hospital services, including pools in rehabilitation facilities, sterilization units, or laundries. Moreover, an environmental advantage is evident as the softened water resulting from this process requires less detergent usage. Research has also been conducted into reprocessing and the practicality of reusing dialysate effluent. However, it's crucial to consider the need for substantial prior authorization and a thorough risk management analysis for the successful implementation of such a venture [22,23].

Strategies to Recycle Wastewater

A number of studies on this subject have been conducted, most notably in Australia [10] and Morocco [24], with the concentrate generated by double osmosis being used to irrigate the hospital's green fields and the center's sanitary facilities. In fact, the physicochemical and microbiological characteristics of our discharged concentrate matched WHO/FAO agricultural usage guidelines. FAO guidelines for agricultural purposes [9]. Furthermore, based on influential characteristics, desired wastewater effluent quality, and assumptions from previous literature, two membrane treatment models (nanofiltration and reverse osmosis) suggested that both approaches were more beneficial than seawater desalination, resulting in a savings (or advantage) of 20-30%. With the exception of hemodialysis wastewater, membrane separation is a frequently employed procedure for treating several types of wastewater [24]. The potential for direct osmosis membranes to recycle waste dialysate by utilizing the dialysis concentration as a drawn solution was investigated. The partially diluted dialysis concentrate can then be diluted further with purified water to generate the dialysate for the subsequent dialysis procedure [25].

CONCLUSION

The study's findings revealed that, in light of climate change issues, the need to conserve water is a shared responsibility. There is a compelling need in the healthcare sector, particularly in hemodialysis, to serve as an instance of effective water management. To achieve this purpose, numerous strategies outlined in this article should be followed. As a result, including awareness campaigns to foster good practices becomes critical for promoting the holistic "one health" perspective. Furthermore, additional study is needed to investigate solid waste and water management in dialysis to improve our expertise in this area.

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