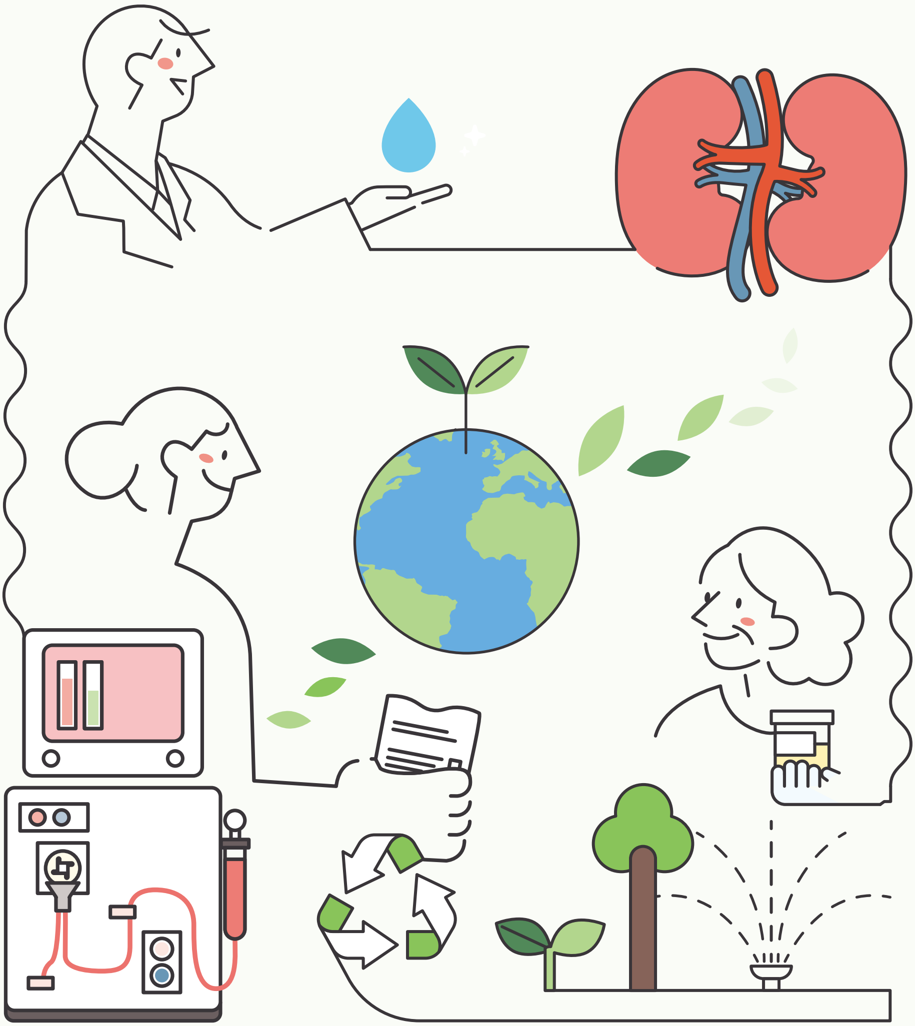
The Korean Society of Nephrology 2024

A Position Statement and Recommendations for Sustainable Kidney Care



THE KOREAN SOCIETY OF NEPHROLOGY

Contents

Recommendation

The climate emergency caused by pollution from human activities is rapidly progressing and is expected to exacerbate in the future. These environmental and climate changes are already affecting the incidence and distribution of kidney disease, and the impact will become more outstanding. It is also believed that the increase in extreme weather conditions caused by climate change may have an unstable effect on providing care for patients with kidney disease. It is known that excessive heat causes severe fluid depletion, increasing the risk of acute and chronic kidney disease. In addition, particle pollution from fossil fuel combustion accelerates the progression of chronic kidney disease and increases the burden of comorbidities. Ironically, healthcare significantly contributes to these environmental problems, causing resource depletion and greenhouse gas emissions. The healthcare sector generates more than 4% of global greenhouse gas emissions, amounting to 8% in some regions. Dialysis is known to have a particularly high environmental impact compared to other medical therapies, suggesting that the nephrological community should play an important role in establishing responsible healthcare guidelines from an environmental perspective.

Embracing this role, the Korean Society of Nephrology will conduct campaigns on this issue as we hold our conference under the principle of 'Green Nephrology.' To this end, various efforts will be needed to strengthen monitoring of the use of resources and waste generation in kidney treatment facilities and to minimize the environmental impact of dialysis treatment. Through this campaign, we will strive to raise awareness of the impact of the environment on kidney disease and the impact of our treatment process on the environment, as well as to promote empathy about the importance of our role. Also, we will carry out kidney health promotion activities about the seriousness to the public and work with related academic societies and health authorities to develop a national response strategy. As one of these activities, the Special Committee of Sustainable Renal Treatment of the Korean Society of Nephrology led the publication of the Sustainable Kidney Care Recommendation. This recommendation will be a basis for creating guidelines that will specify efficient response measures and management goals to reduce the environmental impact of dialysis treatment. We hope this will help in developing systematic and practical measures in the future.

The Korean Society of Nephrology will continue to take the lead in preventing and treating kidney disease in Korea. Thank you.

June 13, 2024

Chun Soo Lim, President of the Korean Society of Nephrology

Introduction

Several recent studies have underscored the correlation between the deterioration of environmental conditions and the exacerbation of kidney disease and renal function decline. Paradoxically, the treatment regimen of kidney disease patients, in particular resource-intensive procedures such as dialysis, entail resources and by-products that impart a significant burden on the environment. In response, the Korean Society of Nephrology articulates its steadfast commitment to mitigating the ecological repercussions of kidney disease treatment and fostering resilient and Sustainable Kidney Care. The Society proffers actionable recommendations for reducing the environmental impact of various forms of dialysis treatment, and aspires to spearhead the journey towards Sustainable Kidney Care through concerted efforts aimed at advocacy and furthering members' proactive engagement.

The Recommendations for Sustainable Kidney Care detailed today represent the Society's inaugural stride towards advancing the sustainable transformation of kidney care. It aims to build upon this model of clinical change to launch a broader array of research initiatives, culminating in the formulation of targeted protocols for pragmatic application in the field.

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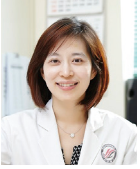

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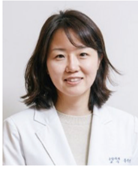

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Hemodialysis

Hemodialysis Key Messages

1.1 It is crucial to make proactive efforts to decrease Reject Water when producing dialysate in Hemodialysis.

1.1.1 We advise to closely monitor and measure the Reject Water production and the recirculation rate of the RO machine water filters in a regular basis for effective use and conservation of water resources.

1.1.2 We advise to consider using various ways in different perspectives to reduce Reject Water.

1.2 It is crucial to make proactive efforts to reuse Reject Water when producing dialysate in Hemodialysis.

1.2.1 We suggest Reject Water as a resource that may potentially be reused and recycled according to local demands.

1.2.2 To determine its suitability for reusing Reject Water, we advise to examine the components of Reject Water.

1.3 Decreasing the dialysate flow rate (Qd) can be considered as a way to save the water resources as long as the efficiency of Hemodialysis is undamaged.

1.3.1 When Qd is lowered by 20%, from the current standard of 500 ml/min to 400 ml/min, a maximum of 100 liters of water can be saved from a single HD session.

1.3.2 We suggest HD with Qd of 400 ml/min to save water, because there is no significant difference in dialysis adequacy and/or short-term clinical outcome compared to Qd of 500 ml/min.

1.3.3 Application of automatically adjustable Qd function may be considered for reducing water in HD, if available.

2.1 We recommend that the total wastes in the dialysis unit should be primarily classified into medical waste and non-medical waste according to the guidelines of the respective region.

2.1.1 In Korea, medical waste is classified into infectious medical waste, hazardous medical waste, and general medical waste.

2.1.2 If general waste happens to be not separated from medical waste and is discharged in a mixed state, it is then considered as medical waste, leading to increased disposal volume and costs.

2.2 To reduce medical waste in the dialysis unit, the eco-friendly Design For Environment is important from its manufacturing stage, and we suggest that the application of this design should be extended not only to dialysis equipment and consumables, but also to the entire dialysis system.

2.2.1 To effectively reduce medical waste of dialysis unit, we suggest that manufacturers apply a Design For Environment to dialysis equipment and consumables.

2.2.2 Although the Central Dialysis fluid Delivery System (CDDS) is expected to have an advantage over the Single-Patient Dialysis fluid Delivery System (SPDDS) regarding medical waste generation, clinical safety aspects must also be considered in use.

2.3 For the recycling of waste from dialysis unit, we suggest that clear classifying recyclable items among general waste according to local guidelines, and enhancing education for working personnel to ensure actual recyclability.

2.3.1 To promote the recycling of dialysis-related waste, we suggest clarifying recyclable items and establishing standardized protocols for disposal methods based on the medical fields.

2.3.2 We suggest reinforcing education for personnel regarding the proper classification and processing of recyclable dialysis-related items and conducting continuous monitoring.

2.4 The reuse of dialysis-related items is extremely limited due to infection, but the dialyzer reuse may be considered in terms of expanding healthcare provision depending on economic consideration. However, strict disinfection standards must be observed, and studies on safety and systemic cost-benefit analysis should be accompanied.

3.1 We suggest considering energy optimization of Hemodialysis facilities.

3.1.1 We suggest the installation and utilization of facilities that maximize energy efficiency in Hemodialysis units, such as lighting, heating, ventilation, and insulation.

3.1.2 We suggest considering the maximum use of renewable energy sources to supply power to the Hemodialysis unit.

3.1.3 Consider actively applying and managing methods to reduce unused energy in the facility (installing sensors in locker rooms, managing to cut off power to machines that are not in use, and applying a master switch to turn off power during all non-operating hours in the dialysis unit).

3.2 We encourage all members of the Hemodialysis unit to actively participate together in energy-saving.

3.2.1 Corporations: Strive to develop additional optimization models for existing dialysis equipment to maximize energy efficiency.

3.2.2 Academic societies and governments: Propose standardized guidelines to promote the design and use of energy-efficient dialysis rooms and the use of Eco-Reporting Systems.

3.2.3 Consider including education on energy conservation and carbon neutrality in patient and staff education programs to spread environmental conservation cuture and change individuals' environmental awareness.

4.1 In order to reduce carbon footprints in the Hemodialysis treatment process, we propose to educate patients and medical staff to actively utilize public transportation.

Chapter 1
The Recommendations for Water Conservation in Hemodialysis

Key Messages

1.1 It is crucial to make proactive efforts to decrease Reject Water when producing dialysate in Hemodialysis.

1.1.1 We advise to closely monitor and measure the Reject Water production and the recirculation rate of the RO machine water filters in a regular basis for effective use and conservation of water resources.

1.1.2 We advise to consider using various ways in different perspectives to reduce Reject Water.

Current Issues

Maintenance Hemodialysis (HD) is a treatment that consumes large quantities of water. Thrice-weekly, 4-hour sessions with a dialysate flow rate of 500 mL/min consumes approximately 20,000 L of water per year, and Hemodiafiltration (HDF) consumes 10~30% more water than standard HD [1]. Priming, rinsing, and sterilization of dialysis machines also require water. Generation of dialysis-quality water through Reverse Osmosis (RO) treatment system necessarily generates Reject Water to dissolve away heavy metals and endotoxins. However, the term “Reject Water” may be a misnomer since it has already passed through multiple filters before being discarded (Figure 1). Generally, most Hemodialysis facilities discard a part of

Reject Water into the sewer system, while reusing another part of the rest of the Reject Water by recirculating it through the RO membrane.

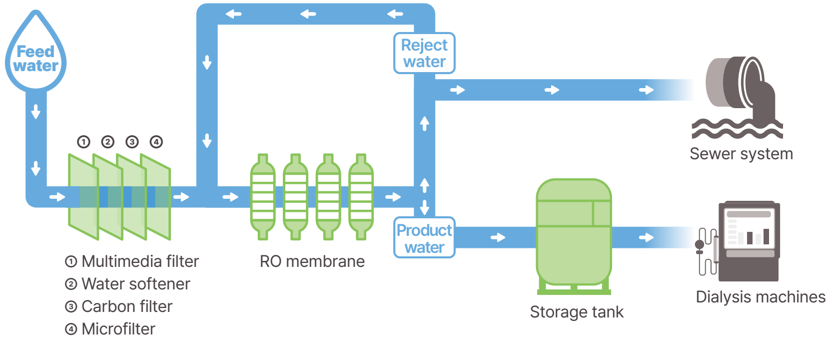

Figure 1 Reject Water production during Reverse Osmosis and its subsequent disposal

Multiple factors affect the amount of Reject Water produced, including water treatment system design and feed water temperature. Low-efficiency RO systems reject up to 60~70% of feed water, while upgraded water treatment systems can lower this ratio down to 20%. High-efficiency RO systems are advantageous because they conserve up to 50% of feed water (feed water quality is an important consideration), but they can be more expensive and the lifespan of filters is sthorter than that of low efficiency systems [2]. Korea is especially advantageous in this aspect, as most water sources have low mineral content and water treatment systems produce good quality, non-fouling feed water. Temperature of the feed water also affects the amount of Reject Water, where high temperature increases the amount of product water, while low temperature decreases it [3]. In Korea, where there are four distinct seasons, more product water tends to be produced during summer months, from May to September. A single center study in Korea shows an average Reject Water of 30~40%, depending on temperature (Figure 2).

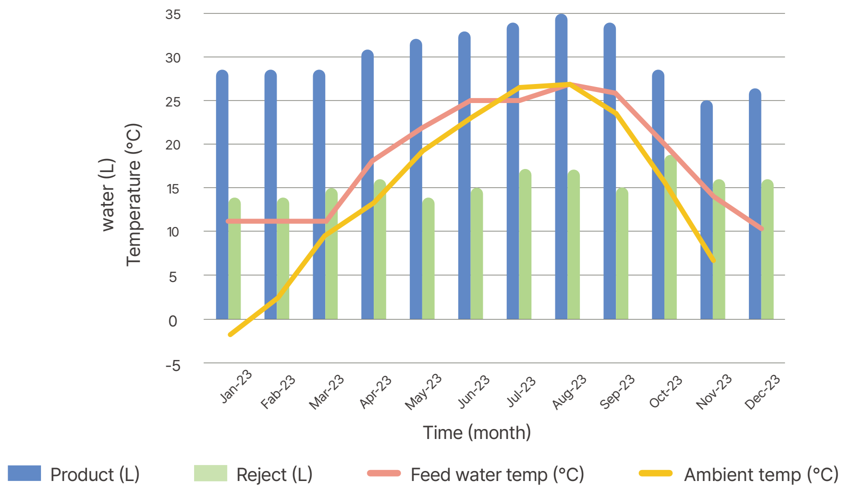

Figure 2 The amount of Reject Water production for one year in a single center

Statements

Although both feed water and recirculated Reject Water is used in dialysate, most manufacturers focus on maintining stable pressure of the reverse osmotic membrane and the efficiency of the machine, making it difficult to study on how much Reject Water is recirculated and how it affects RO water production. Therefore, various fields' involvement is needed from Reverse Osmotic membrane designers and nephrologists, to government agencies. In addition, more research should be devoted to Reject Water composition and developmental design to assess the quantity of Reject Water that is discarded and/or revised. To improve water usage monitoring, it is recommended to develop a method involving the installation of water meters. Specifically, these meters should be placed on the incoming water pipes of RO systems to measure both the total water usage and the amount of water used per treatment.

Key Messages

1.2 It is crucial to make proactive efforts to reuse Reject Water when producing dialysate in Hemodialysis.

1.2.1 We suggest Reject Water as a resource that may potentially be reused and recycled according to local demands.

1.2.2 To determine its suitability for reusing Reject Water, we advise to examine the components of Reject Water.

Current Issues

Conventionally, Reject Water is discarded into the sewer system and to this date, there has been no known documentation of efforts to reuse Reject Water in Korea for other pragmatic purposes. In terms of colony counts, Reject Water fits the criteria for agricultural use and potable water, but needs to go through Demineralization and Desalination process for dialysis because of its high conductivity. Although there are only a few studies investigating the potential of Reject Water, a study conducted in Malaysia by Eason et al. analyzed the composition of Reject Water [Table 1] [4].

Water test parameter	unit	Feed water	Reject Water	RO water
Aluminum	mg/L	0.061	0.015	<0.001
Copper	mg/L	0.001	0.001	<0.001
Fluoride	mg/L	0.43	0.78	0.05
Nitrate	mg/L	0.6	1.0	<0.1
Sulphate	mg/L	7	13	<2
Zinc	mg/L	<0.001	<0.001	<0.001
Barium	mg/L	0.010	0.015	<0.001
Calcium	mg/L	4.73	9.72	<0.001

Magnesium	mg/L	0.77	0.80	<0.001
Sodium	mg/L	2.72	4.17	0.45
Potassium	mg/L	3.24	4.87	0.024
Total chlorine	mg/L	1.58	0.05	<0.02
Arsenic	mg/L	<0.001	<0.001	<0.001
Lead	mg/L	<0.001	<0.001	<0.001
Silver	mg/L	<0.001	<0.001	<0.001
Chromium	mg/L	<0.001	<0.001	<0.001
Selenium	mg/L	<0.001	<0.001	<0.001
Mercury	mg/L	0.0002	<0.0001	<0.0001
pH value	mg/L	7.5 @25°C	7.0 @25°C	6.3 @25°C
Total Dissolved Solid	mg/L	53.2	85.4	1.79
Hardness	mg/L	15.01	27.56	<1
Antimony	mg/L	<0.001	<0.001	<0.001
Beryllium	mg/L	<0.0001	<0.0001	<0.0001
Thallium	mg/L	<0.001		<0.001
Total viable Microbial, TSA 35c for 48h	Cfu/mL	<1	59	2

Table 1 The composition of feed water, Reject Water, and RO water

Globally, there are a few dialysis centers that recycle Reject Water by use of a redirecting system [3]. These centers utilize Reject Water according to local needs and resource availability. In Malaysia, treated Reject Water is used for fish breeding and vegetable farming [Figure 3]; in Australia, Reject Water is used to generate steam for medical equipment sterilization, and in Morocco, demineralized Reject Water is used for irrigation of garden and landscape plantings.

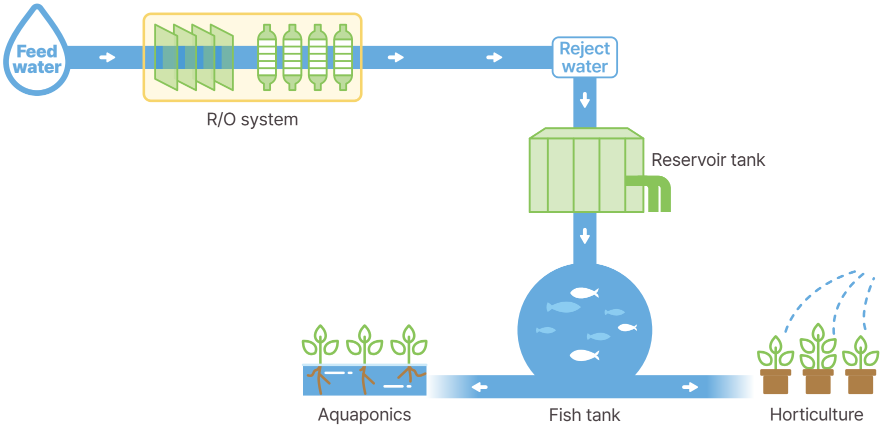

Figure 3 Reuse of Reject Water in Malaysia

Reject Water has a high conductivity and must be demineralized prior to use for irrigation or industry. The amount of treatment needed varies depending on the intended use of Reject Water. Multiple methods of water treatment, such as distillation, evaporation, and Electrodialysis, are currently being investigated in terms of cost-benefit and safety, but there is no clear evidence that a single method is superior. Therefore, despite the obvious benefits for ecology, the cost for water treatment and potential space for storage of "treated" Reject Water must take into consideration when discussing the efforts to reuse Reject Water.

Statements

We should make efforts to reuse Reject Water according to local needs. Cost benefit analysis compared with other forms of water generation, such as seawater desalination, and analysis of the economic impact of reduced wastewater are needed to validate the utility of Reject Water treatment.

In overseas cases, Reject Water is used in various ways such as cleaning, agriculture, and fish farming; there are many ways of using treated and clean water. In Korea, it is also difficult to say that it is always beneficial to treat and store Reject Water, because we need to consider location of artificial kidney centers (whether it is located in the city or the country area) or land usage of nearby area (farmland, sea, etc.). Thus, we need to discuss various possibilities in connection with the local communities.

Future Perspectives

Ultimately, we propose to attain a "Zero Liquid Discharge Policy" where no feed water is wasted during dialysis.

Current Issues

With increasing water shortage and concern about the environmental impact of Hemodialysis, more attention should be given to reducing, reusing, and recycling Reject Water. In this proposal, we consider how to reduce, reuse, and recycle Reject Water to promote a more eco-friendly and Green Nephrology.

Statements

For the future, Green Nephrology in Korea should aim to attain a "Zero Liquid Discharge Policy," where all feed water, including Reject Water, is dialyzed or recycled. This process consists of many steps including ultrafiltration, Reverse Osmosis, evaporation, and Electrodialysis. The installation of water treatment systems may be complex and costly, but in the long term, such efforts will be cost-effective and eco-friendly. At the time of drafting, such process has been applied to dialysis only in theory, but its possibility is well under investigation and there are projects being conducted using advanced technology. Further research and funding will be necessary to attain this goal through the joint effort of nephrologists, government officials, and RO manufacturers. Future directions of study should focus on the composition and quantity of Reject Water produced in different dialysis facilities in Korea, as well as creative methods of reusing Reject Water to match local demands and necessities.

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Key Messages

1.3 Decreasing the dialysate flow rate (Qd) can be considered as a way to save the water resources as long as the efficiency of Hemodialysis is undamaged.

1.3.1 When Qd is lowered by 20%, from the current standard of 500 ml/min to 400 ml/min, a maximum of 100 liters of water can be saved from a single HD session.

1.3.2 We suggest HD with Qd of 400 ml/min to save water, because there is no significant difference in dialysis adequacy and/or short-term clinical outcome compared to Qd of 500 ml/min.

1.3.3 Application of automatically adjustable Qd function may be considered for reducing water in HD, if available.

Current Issues

Currently, a dialysate flow rate of 500 ml/min is widely accepted as the standard in HD. Modern development in hemodialyzer design and hollow fiber manufacture improved dialysate flow in dialyzers, enabling higher Clearance at the same flow rate [1]. If Qd is decreased by 20% and lowered to 400 ml/min, 24 to 100 L of water can be conserved per session, taking into account of Reject Water from low-efficiency Reverse Osmos is (RO) systems [2]. However, the trade-off between saving water and lower solute removal raises a concern for patient outcome.

Similar to HD, Qd of 500 ml/min is also recommended for Online Hemodiafiltration (OLHDF). To determine whether higher dialysate flow rate increased solute removal, Albalate Ramon et al. reported a prospective cross-over trial with 37 patients [3]. OLHDF with a higher Qd at 600 and

700 ml/min increased Kt by 1.7% at the expense of increased water usage by 20% and 40%, respectively. This study showed that increasing Qd more than 500 ml/min in OLHDF only marginally increases solute removal, making it questionable whether this difference is even clinically meaningful. However, if further reductions can be made in Qd, there can be more significant outcome in water usage reduction.

Recently, some dialysis machines are equipped with a function that allows for automated adjustment of Qd, making it possible to reduce the amount of water used in dialysis [2, 5]. For example, the AutoFlow option installed on FMC 5008 machines automatically adjusts Qd to 1.5 times the blood flow rate (Qb). A single center conducted in the United Kingdom showed a 9% reduction in water use when using the AutoFlow function, which they estimated to conserve about 1140 cubic meters or 400 tons of water per year and reduce annual carbon dioxide emissions by 3715 kg CO_2e [6]. Mesic et al. reported a randomized cross-over trial comparing OLHDF using AutoSub and AuoFlow function of FMC 5008 equipment and high-flow HD in 54 patients for 6 weeks [7]. Their results showed that dialysate use decreased by 8% in the OLHDF group compared to HD group, while Kt/V was 3.5% higher, suggesting that application of automated Qd control in HDF helps reduce dialysate use without loss of efficiency. Canaud et al. recommended that the ratio of Qd to Qb should be maintained at 1.4 times when applying HDF, which is consistent with the current setting by the AutoFlow module [8].

We conducted a review of clinical studies that investigated the effect of various lower Qd on solute removal (Kt/V, Kt, or beta2-microglobulin

(β_2MG)) and/or clinical outcomes such as potassium and phosphate levels in HD patients. A systemic review by Molano-Trivino et al. extracted a total of 816 studies, published from Jan 1980 to June 2017, and we selected 11 studies [9]. Among them, we excluded five studies because of their low relevance to the current situation in Korea. The results are summarized in Table 1 [10-15]. When Qd was reduced to less than 500 ml/min, decreased removal of low molecular weight toxins was observed in most studies, but its impact was estimated to be insignificant, and there was no change in the serum level of potassium, phosphate and β_2MG. Since long-term clinical outcome has not been evaluated, the results of an unpublished Colombian study, which randomly assigned HD patients to a Qd of 400 or 500 ml/min and followed patients over 5 years, is awaited.

When applying the same approach to OLHDF, we found that Maduell et al. assessed the reduction ratio of urea, creatinine, and β_2MG during each 5 sessions using various Qd between 300 and 700 ml/min in 59 patients on Post-dilution OLHDF [10]. There was no difference in Convection volume among various Qd rates, and reduction of Qd from 500 to 400 and to 300 ml/min resulted in lowering of Kt from 73, 71, to 68L and Urea Reduction Ratio (URR) from 84.1%, 83.6%, to 82.5%, respectively without a change in middle molecule removal [10]. Nevertheless, it would be prudent to await other studies. Alternatively, Expanded HD using medium cut-off (MCO) dialyzers such as Theranova® or Elisio Hx® would provide additional options for effective removal of middle molecule compared to Conventional HD, without consuming more water than OLHDF.

Statements

Considering the aforementioned results, HD with a Qd of 400 ml/min is a method that can be applied without significant reduction in dialysis efficiency and clinical outcome compared to the conventional 500 ml/min and can also conserve water. If available, use of automated regulation of dialysate flow rate is a potential tool for reducing dialysate use and thus water use.

Author (year)	Study subject	Study design	Membrane	Qd (ml/min)	Follow up duration	Outcome	Conclusion	Reference
Kirchner (1984)	N=20; Chronic stable HD, x3/week, acetate HD	Before-/after study	Rexeed-15 (Gambro)	500 (baseline) → 300	12 & 24 months	Kt/V, serum chemistries, blood pressure, nerve conduction, EEG	No difference between Qd 500 vs 300 ml/min; Qd 300 is associated with ↑P which appears to be self-limiting	[11]
Hauk (2000)	N=23; stable HD x3/week	Single center, cross-over design	GFS Plus 20, Polyflux 14, 17, and 21	300 vs 500	6 weeks	Kt/V increased from 1.19 @ Qd 300 to 1.32 @ Qd 500	The proportion of patients not achieving Kt/V > 1.2 was reduced from 56% at Qd 300 to 30% at Qd 500	[12]
Bhimani (2010)	N=12; stable HD x3/week with BFR 400	Single center, cross-over	Optiflux F160NR, F200NR, Revaclear and Revaclear MAX	350 vs 500	12 weeks	Clearances of urea, phosphate, b2MG	Clearances of urea and phosphate, but not β2-microglobulin, increased significantly with increasing Qd ; but no significant effect on KoA	[13]
Alayoud (2012)	N=33; Stable HD x 3/week, expected fluid removal < 3 L	Single center, cross-over design	Polyflux H 140, 170, 210	Autoflow (404) vs 500	6 weeks	Kt/V was 1.50 at Qd 500 and 1.49 with AF	increasing Qd more than the model of AF predicted had a small effect on the delivered HD dose	[14]
Albalate (2015)	N=22; stable HD, x2 or x3/week	Prospective single center cross-over study	Xenium H, Xenium Nm FX80, Polyflux 210	500 (6 sessions) vs 400 (6 sessions)	6 months	Kt	Increasing Qd from 400 to 500, Kt increases by 4%; but Identical Kt could be obtained with Qd of 400 and 500, increasing dialysis time 9.1' and saving 20% of dialysate	[4]
Molano_Trivino (2018)	N=46; stable HD, x3/week, body weight < 65kg	Rando mized, cross-over	Xenium 110 and 130	400 vs 500	8 weeks	No difference in Kt/V	The reduction in Qd in small patients has no impact in terms of Kt/V, interdialytic weight gain, blood pressure and electrolytes	[15]

Table 1 Effects of low dialysate flow rates (Qd) compared with standard Qd at 500 ml/min in Hemodialysis patients

Future Perspectives

Clinical trials are required to verify the long-term outcome of Qd reduction in Hemodialysis and Hemodiafiltration patients and to reveal the new Hemodialysis techniques for reducing usage of water.

Current Issues

So far, no studies have investigated patient survival rates or major clinical outcomes. Therefore, clinical studies are needed to compare and evaluate long-term results when the dialysate flow rate is lowered in HD and HDF patients.

In addition, new methods that can reduce dialysate and water use are emerging along with the development of Hemodialysis technology. For example, Sorbent Dialysis, which reclaims used dialysate by recirculating it through the specialized membrane, only requires about 6 liters of water, so if commercialized, it is expected to have great effect in reducing water use [1]. Home HD using equipment such as NxStage, which only uses approximately 10% of water compared to conventional HD, is also a way to save water [16]. Recently, efforts to develop a system for Home HD are active in Korea, but these efforts must be matched with methods for proper reimbursement system to support Home HD. In addition, it should be noted that Home HD using conventional HD equipment may increase water use further as the number and time of dialysis sessions increase, and in the case of Sorbent Dialysis, carbon footprints for consumables including zirconium integrated membranes may increase [17].

Statements

New technology, such as Sorbent Dialysis and water-conserving Home HD equipment offer a promising future for Green Nephrology but must be backed by clinical trials showing long-term outcomes in both HD and HDF patients.

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Chapter 2
The Recommendations for Waste Reduction in Hemodialysis

Key Messages

2.1 We recommend that the total wastes in the dialysis unit should be primarily classified into medical waste and non-medical waste according to the guidelines of the respective region.

2.1.1 In Korea, medical waste is classified into infectious medical waste, hazardous medical waste, and general medical waste.

2.1.2 If general waste happens to be not separated from medical waste and is discharged in a mixed state, it is then considered as medical waste, leading to increased disposal volume and costs.

Current Issues

According to WHO guidelines, medical waste is defined as "the total waste stream from a healthcare facility" [1], but regulations for classifying and managing medical waste vary by region [Table 1]. In Korea, medical waste is a designated waste subject to the Waste Control Act and is divided into infectious medical waste, hazardous medical waste, and general medical waste; among three, hazardous medical waste is further categorized into five types as shown in Table 2. Medical waste in Korea is managed through dedicated containers, sealed storages, collection and transport through dedicated vehicles, and incineration, under Radio-Frequency Identification System [Figure 1], and the details are as in Table 2. As of 2018, 13 designated companies are in charge of medical waste, but as the amount of medical waste increases rapidly every year, designated incinerators are almost saturated, and the unit cost of processing is also rising. In the dialysis unit, several kilograms of waste are generated per single dialysis session, which includes not only needles, lines and dialyzer that come in contact with the patients' blood, but also diverse items such as dialysate containers, packing paper and cardboard. If these are not properly separated from general waste according to guideline and discharged with mixed state, general waste is then considered as medical waste, resulting in the increased discharge volume and significant processing costs. In an online survey conducted at 126 general hospitals in Korea, it was found that 29 hospitals (23%) disposed of medical waste in general waste containers and 66 hospitals (55%) disposed of general waste in medical waste containers. According to the study by Piccoli GB et al., depending on the degree of separation of medical waste in the dialysis unit, the amount of hazardous medical waste per dialysis session showed a large difference ranging from 1.11 kg to 8.09 kg, leading to significant differences in processing costs from 2.97 dollars to 21.67 dollars [4]. These results show how important proper classification of medical waste and general waste is primarily in reducing medical waste generation.

Statements

We recommend that total waste generated in the dialysis unit to be primarily classified into medical waste and general waste. This will reduce the mixed discharge of general waste and medical waste, decreasing the excessive discharge of medical waste and processing costs.

	South Korea	WHO	EU	USA	Japan
Terminology	Medical waste	Health-care waste	Health-care waste	Medical waste	Infectious waste
Classification of medical wastes			EWC° code		
Sharps	Sharps	Sharps	18 01 01/ 18 02 01	Contaminated sharps/ Unused sharps	Infectious industrial
Body parts and organs including blood bags and blood preserves	Body parts and fluids/ Blood contaminated/ Pathological test	Pathological	18 01 02	Bulk human blood/ pathological wastes	Infectious municipal
Waste whose collection and disposal is subject to special requirements in order to prevent infections	Infectious	Infectious	18 01 03*/18 02 02*	Isolation/Cultures and stocks of infectious agents and associated biological/animal wastes	Infectious industrial/ Infectious municipal
Wastes whose collection and disposal is not subject to special requirements in order to prevent infection (e.g,dressings, plaster casts, linen, disposable, clothing, diapers contaminated with blood etc.)	General	Infectious	18 01/04/ 18 02 03		Infectious municipal

Chemicals consisting of or containing dangerous substance	Biological/Chemical	Chemical	18 01 06*/18 02 05		
Chemicals other than those mentioned in 18 01 06*	Biological/Chemical	Chemical	18 01 07/ 18 02 06	Small volumes of chemical hazardous waste	
Cytotoxic and cytostatic medicines	Biological/Chemical	Cytotoxic	18 01 08*/ 18 02 07*	Antineoplastic drug	
Chemicals other than those mentioned in 18 01 08*	Biological/Chemical	Pharmaceutical	18 01 09/ 18 02 08	Small volumes of chemical hazardous waste	
Amalgam waste from dental care		Chemical	18 01 10		
EU Proposal: COM(2003) 32 final		Radiological		Low-level radioactive waste	

Table 1 Comparison of definition and classification system of medical waste in each country

Waste type		Storage Facility	Container/Color	Storage period
Medical Waste for Quarantine (Infectious medical waste)		Refrigerated storage/transportation	Plastic container (red)	Discharge: 7 days Transportation and incineration: 2 days each
Hazardous medical waste	Tissues	Refrigerated storage/transportation	Plastic container (yellow)	Discharge: 15 days (60 days for teeth) Transportation: 5 days, processing: 2 days
	Injurious	Room temperature storage, refrigerated transportation	Plastic container (yellow)	Discharge: 30 days Transportation and incineration: 5 days each
	Pathological	Room temperature storage, refrigerated transportation	Liquid: Plastic Solid: Corrugated cardboard (yellow)	Discharge: 15 days Transportation and incineration: 5 days each
	Biochemical	Room temperature storage, refrigerated transportation	Liquid: Plastic Solid: Corrugated cardboard (yellow)	Discharge: 15 days Transportation and incineration: 5 days each
	Blood-contaminated	Room temperature storage, refrigerated transportation	Liquid: Plastic Solid: Corrugated cardboard (yellow)	Discharge: 15 days Transportation and incineration: 5 days each
General Medical Waste		Room temperature storage, refrigerated transportation	Liquid: Plastic Solid: Corrugated cardboard (yellow)	Discharge: 15 days (30 days if refrigerated) Transportation and incineration: 5 days each

Table 2 Classification and management of medical wastes in South Korea

Brochure from the Ministry of Environment for 2022

Figure 1 Overview of medical waste management based on Radio-Frequency Identification system in South Korea

Statements

Korea is unique in operating a “Dedicated Incinerator” system for medical waste [5]. As of 2018, 15 incinerators are in operation, but there are only 3 in the metropolitan area, where medical waste is concentrated, so the distance for medical waste to be moved to regional areas and incinerated is long. Therefore, expansion of dedicated incinerators for medical waste and effective regional deployment should be discussed, and regulations related to diversification of medical waste disposal methods should be reviewed.

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Key Messages

2.2 To reduce medical waste in the dialysis unit, the eco-friendly Design For Environment is important from its manufacturing stage, and we suggest that the application of this design should be extended not only to dialysis equipment and consumables, but also to the entire dialysis system.

2.2.1 To effectively reduce medical waste of dialysis unit, we suggest that manufacturers apply a Design For Environment to dialysis equipment and consumables.

2.2.2 Although the Central Dialysis fluid Delivery System (CDDS) is expected to have an advantage over the Single-Patient Dialysis fluid Delivery System (SPDDS) regarding medical waste generation, clinical safety aspects must also be considered in use.

Current Issues

In general, 70% of a product's impact on the environment is determined at the design stage of the manufacturing. In particular, since most of the items discharged from dialysis unit come in contact with blood and are classified as medical waste, design to minimize the amount of waste is very important. Design For Environment refers to a design approach to reduce the environmental impact of products, processes or services in the whole life cycle of the device usage [1] while maintaining the basic function of products. It includes the eco-friendly materials, miniaturization, weight reduction, and the 3R applicability. With the recent visualization of global corporations' ESG declarations and national-level movement to legislate ESG, manufacturers in the dialysis-related industry are also paying attention to the production of dialysis equipment and consumables following environmentally friendly policies.

Company F's 6008 CARE system dialysis machine is designed to be approximately 100 g lighter than previous models by incorporating features such as an All-in-one cassette system of blood and dialysate lines and lightweight plastic materials like biofin. Furthermore, it is equipped with an automatic emptying function of blood, dialyzer and bibag to minimize the final weight of waste. Additionally, Di-Ethylhexyl Phthalate (DEHP)-free Polyvinyl Chloride (PVC) was used in the lines, and the amount of PVC was reduced by 22 % compared to the existing model (DEHP is used as a plasticizer for plastics and is classified as an environmental hormone, and PVC is a representative plastic that is harmful to the environment) [1,2]. Company B's AK98 model is designed to be 50% lighter than the existing Artis Physio Plus model through miniaturization, reducing the packaging volume by 51% from 33 kg to 16 kg. In addition, the replacement cycle of parts was extended by 50% by increasing the efficiency of the machine [3]. The containers of Acid concentrate and Bicarbonate concentrate are also examples of the application of environmentally friendly design. By changing the design from plastic containers to bags, it became easier to empty the contents and fold, ultimately reducing the volume of waste during medical waste disposal [4]. These demonstrate how product design geared towards environmental friendliness, according to manufacturers' environmentally friendly policies, can effectively reduce the quantity of medical waste regardless of the efforts of healthcare workers.

The dialysis fluid delivery system is broadly divided into Central Dialysis fluid Delivery System (CDDS) and Single-Patient Dialysis fluid Delivery System (SPDDS) [5]. In Korea, the Central Dialysis fluid Delivery System accounts for about 12%, and most use the Central Concentrate Delivery System (CCDS), which supplies only A concentrate. An Italian study in which 11,000 dialysis treatments were performed with CCDS in 85% of patients over 1 year reported a saving of 25,220 euros by reducing 11,470 kg of plastic material and 7,150 kg of Acid concentrate residuals. It also showed that the movement/management of 59,180 kg of material has been avoided with a considerable reduction of the operators and caregivers' effort [6]. As seen above, CCDS is effective in reducing medical waste in that it can decrease concentrate wastage and consumables such as connection lines, and packaging compared to SPDDS. Moreover, there are expected additional benefits in terms of energy consumption related to dialysate transport and storage. However, CCDS requires attention to issues such as infection, system instability, and aspiration when mixing acetic acid, and clinical safety aspects must also be considered.

Statements

Since most of the waste from dialysis unit comes in contact with blood and is classified as medical waste, recycling and reuse are difficult. Therefore, products classified as medical waste should be miniaturized and lightened from the manufacturing stage to reduce total amount of inevitable medical waste, and minimize environmental pollutants during incineration by applying eco-friendly materials.

In addition, packaging should also reduce the total volume by minimizing individual packaging, and recyclable plastic and paper should be used as materials. Therefore, we suggest that Design For Environment should be expanded throughout the dialysis system, as well as dialysis machines and consumables. In addition, the continuous cooperation and efforts between healthcare professionals and manufacturers must be made for the advancement of environmentally friendly dialysis.

Further Perspectives

In the case of Design For Environment, conflicting issues between environmental and economic values may arise due to the manufacturer's development costs. Therefore, it is necessary to increase social awareness of eco-friendly products, and support at the national level is needed.

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Key Messages

2.3 For the recycling of waste from dialysis unit, we suggest that clear classifying recyclable items among general waste according to local guidelines, and enhancing education for working personnel to ensure actual recyclability.

2.3.1 To promote the recycling of dialysis-related waste, we suggest clarifying recyclable items and establishing standardized protocols for disposal methods based on the medical fields.

2.3.2 We suggest reinforcing education for personnel regarding the proper classification and processing of recyclable dialysis-related items and conducting continuous monitoring.

Current Issues

In dialysis unit, apart from needles, syringes, lines, and dialysis filters that come into contact with patients' blood and bodily fluids, which are considered medical waste according to local guidelines, plastic and paper items such as concentrate A (Acid) container, concentrate B (Bicarbonate) container, packaging materials, and boxes can be classified as general waste.

According to Piccoli et al.'s study, non-hazardous medical waste of plastic ranging from 310~730 g and paper from 223~736 g was generated per dialysis session, with only 22.9~28.1% of plastics reported as recyclable [1]. Typically, seeing only about 10% of recycled plastics undergo actual recycling processes, this amount is significantly low. The low recycling rate of plastics is primarily due to the difficulty in sorting them and the complexity of uniform recycling processes due to various materials and characteristics [2]. And even if plastics of the same material are collected, recycling is often not feasible due to ink, adhesives, and additives. Currently, plastics are categorized into seven types to increase recyclability: PETE, HDPE, PVC, LDPE, PP, PS, and OTHER [Table 1]. They are categorized based on the plastic Resin Identification Code to increase recycling rates, and these codes are usually written on the back or bottom of plastic product. For effective recycling of dialysis unit items, paper should be discharged without contamination, with foreign substances removed, while plastics should be sorted and cleaned according to Resin Identification Codes, grouping items by the same material and color.

Several studies have reported that nurses with a higher level of knowledge about medical waste have a positive attitude toward medical waste have a higher degree of practice, and that there is a significant correlation between age, educational background, department, position, and medical waste education as factors affecting practice [3, 4]. This shows how important it is to continuously educate and promote medical waste for medical workers.

Statements

Table 2 shows the classification of recyclable items among the total medical waste generated in the dialysis unit and the general waste according to the Korean guidelines. In fact, Acid concentrate container is excellent resources for recycling, but the treatment process is not consistent because hospitals select their own companies and dispose of them on consignment. Therefore, standardization of protocols for recyclable items and treatment methods should be established in relation to recyclable items of dialysis unit. In addition, in order to promote actual recycling, training of workers on classification and treatment of wastes should be strengthened, and continuous monitoring should be implemented.

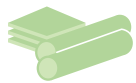
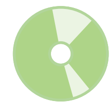
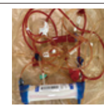
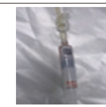
Polymer Name	Polyethylene terephthalate	High-density polyethylene	Polyvinyl chloride	Low-density polyethylene	Polypropylene	Polystyrene	OTHER
Resin Identification Code(RIC)	1 PETE	2 HDPE	3 PVC	4 LDPE	5 PP	6 PS	7 OTHER
Abbreviation	PETE	HDPE	PVC	LDPE	PP	PS	Other or O
Common products	Beverage bottles, Plastic water bottles, Sauce bottles	Milk jugs, Shampoo bottles, Flower pots Grocery bags	Pipes, Siding, Flooring Rain gutters	Plastic bags, Plastic wrap, Ziplock bags Bubble wrap	Yogurt cups, Juice bottles, Straws, hangers	To-go containers	CD case
							
Recycling	Commonly recycled	Commonly recycled	Hard to Recycle	Hard to Recycle	Commonly recycled	Hard to Recycle	NOT Recyclable
Reusability	Should not be used to store water, drinks	Can be reused to store water, drinks	Should not be used to store water, drinks	Can be reused to store dry food	Can be reused to store dry food	Should not be used to store water, drinks	Should not be used to store water, drinks
Recycled into	Clear plastic bottles, Clothing, Carpets	Plastic bottles, Furniture, Ropes	Flooring, Traffic cones, Credit cards	Bins, Floor tiles	Storage Bins, Brooms	Décor products	Can not be recycled

Table 1 Resin Identification Code

Waste	Container (color)			Items		
Medical waste for Quarantine		Liquid: Plastic (red) 	Solid: Plastic (red) 	All waste generated from medical treatment of patients quarantined to protect others from infectious diseases as defined in Article 2, Paragraph 1 of the Act on Prevention and Control of Infectious Diseases (e.g: COVID-19, measles, chickenpox, disseminated herpes zoster and active tuberculosis, VRE, CRE etc)		
Hazardous medical waste	Tissues	Liquid: Plastic (yellow) 	Solid: Corrugated cardboard (yellow) 	Red cell blood 	Fresh frozen plasma 	Platelet 
	Injurious			Fistular needle 	Syringe needle 	
	Pathological			Blood culture bottle 		
	Biochemical			Heparin 		
	Blood-contaminated			Line and dialyzer 	Heparin syringe 	Saline syringe 

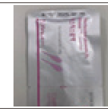
Waste	Container (color)			Items		
General medical waste	Liquid: Plastic Solid: Corrugated cardboard (yellow)	Liquid: Plastic (yellow)	Solid: Corrugated cardboard (yellow)	Disposable Technician gown	Disposable Poly glove	Disposable Latex glove
						
				Disinfecting wipe	Disposable Povidone-Iodine Swabsticks	Sterile Gauze
						
General Waste	Recyclable			Acid concentrate Container	Disinfectant Container	
						* Container body: HDPE(2) Container cap: PP(5)
				Packaging(paper)	Packing(plastic)	
						
	Non-recyclable			B-cartrige	Bibag	
						* The container of Bicart is recyclable, but it is difficult to empty the content, it is classified as general work-palce waste

Table 2 Medical waste management and recyclable items in dialysis unit

Future Perspectives

As mentioned above, there are limitations to increasing the recycling rate only through the waste separation by the dialysis unit, so various methods to compensate for this should be discussed. In 2022, a domestic manufacturer has promoted upcycling as part of ESG by collecting concentrate containers free of charge through an agreement with a recycling company to transform them into cosmetic containers, and if all 210,000 containers per month currently used are recovered, it is expected to save 1,416 tons per year [3]. In the case of Acid concentrate container, it is an excellent recyclable plastic composed of HDPE and PP materials. In addition, in the case of B cartridge, the container can be recycled since it is PP material, but it is difficult to empty the contents, which is why it is currently being discarded as general waste. Therefore, it is necessary to discuss the application of the Extended Producer Responsibility (ERP) for items that are easy to recycle among dialysis-related waste. In addition, research on indicators that can quantify and monitor the waste generation and recycling rates in dialysis unit is also needed.

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Key Message

2.4 The reuse of dialysis-related items is extremely limited due to infection, but the dialyzer reuse may be considered in terms of expanding healthcare provision depending on economic consideration. However, strict disinfection standards must be observed, and studies on safety and systemic cost-benefit analysis should be accompanied. Additionally, it is essential to investigate the environmental impact of the disinfectant chemicals used. While the reuse of dialyzers may reduce solid waste, it could potentially increase liquid waste and environmental pollution

Current Issues

In the past, dialyzer was reused to expand healthcare provision by reducing costs, but many countries now prohibit the dialyzer reuse due to risks such as infection and exposure to disinfectants. However, it is still necessary to dialyzer reuse in developing countries, and based on 50 years of clinical experience, there is a general agreement that the reuse process is generally safe when there is a strict compliance with the standards set by the Association for the Advancement of Medical Instrumentation (AAMI) [1]. In fact, studies showed that the reuse of dialysis filters with strict disinfection standards does not increase patient morbidity and mortality [2]. Therefore, depending on the country's economic situation, the reuse of dialyzer may be considered.

Statements

In Korea, reusing the items such as dialyzers and Bicarbonate cartridges is not recommended due to the risk of infection. However, depending on economic consideration of each country, the dialyzer reuse can be carefully considered in order to expand the healthcare provision. However, the dialyzer reuse must comply with strict disinfection standards and should be accompanied by studies on disinfection standards and safety in the region. In addition, since the current dialyzer reuse in developing countries is primarily aimed at cost-saving rather than environmental benefits, it is necessary to decide whether to continue the policy of maintaining dialyzer reuse through systematic cost-benefit analysis.

Future Perspectives

With the recent development of manufacturing technology, research on the development of dialyzer that have a long lifespan and are reusable is being conducted [1]. Depending on the results in the future, the dialyzer reuse may be discussed again in environmental aspects as well as medical cost-saving.

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Chapter 3 The Recommendations for Energy Saving in Hemodialysis

Current Issues/Background

Hemodialysis consumes a significant amount of energy, water, and resources while being practiced repeatedly, with an estimated power consumption of 12~19 kHw per dialysis session [1]. Additionally, Hemodialysis consumes more energy compared to Peritoneal Dialysis [2, 3]. The Europe HD energy consumption report indicates a range of 1,500 to 4,500 kWh per year per Hemodialysis patient, total 825 million kWh per year. Globally, an estimated 5 billion kWh per year is consumed. This is 22 times higher than the electricity consumption of an average household, which is 3,700 kWh per year in Europe [4]. According to a report from the Korean Society of Nephrology, 91.7% (107,015 patients) undergo Hemodialysis three times a week, with 87.7% receiving conventional Hemodialysis except for HDF and others. It is assumed that at least 19.86 million dialysis filters were used in Hemodialysis centers in South Korea in 2023, with a similar number of sessions or more expected to be conducted. Considering the power consumption per hour of Hemodialysis machines available in Korea, ranging from 0.68 kWh to 2.5 kWh, 3.1 to 10 kWh per session and assuming a session duration of 4.5 hours without considering new dialysis initiation or special situations like SLED, the total energy consumption is estimated to be at least 48,873,067.6644 to 179,680,395.825 kWh (about 1.8 billion kWh!) [5]. Compared to the annual energy consumption per capita in Korea in 2022, which was 10,652 kW, the additional energy consumption per Hemodialysis patient is estimated to be approximately 1030.32 kWh per year, resulting in about a 10% increase in energy consumption for each additional Hemodialysis patient. Active monitoring of the actual energy input into the treatment, minimizing wasted energy, optimizing dialysis machine operation time, and centralizing control of all other electrical devices/facilities have been suggested [4]. It is crucial to explore feasible energy-saving practices for Hemodialysis in the context of the current situation in Korea.

Key Messages

3.1 We suggest considering energy optimization of Hemodialysis facilities.

3.1.1 We suggest the installation and utilization of facilities that maximize energy efficiency in Hemodialysis units, such as lighting, heating, ventilation, and insulation.

3.1.2 We suggest considering the maximum use of renewable energy sources to supply power to the Hemodialysis unit.

3.1.3 Consider actively applying and managing methods to reduce unused energy in the facility (installing sensors in locker rooms, managing to cut off power to machines that are not in use, and applying a master switch to turn off power during all non-operating hours in the dialysis unit).

Current Issues

Specific measures to reduce electricity demand in dialysis facilities is still lacking. However, since various electrical appliances such as dialysis machines, computer devices for treatment, lighting, heating, and air conditioning are already used in all dialysis facilities, eco-friendly strategies for general households can also be applied and implemented.

Given that immunocompromised dialysis patients frequent these rooms, maintaining an appropriate temperature is crucial. Therefore, reinforcing insulation materials and window systems in buildings housing dialysis rooms is essential for energy conservation. Opting for lighting and heating systems with high energy efficiency is also important. Additionally, considering using timers for air conditioning to regulate cooling and heating times and increasing overall efficiency with air conditioning systems are feasible options.

There are reports indicating that replacing traditional incandescent bulbs with low-power LED bulbs can reduce energy consumption by approximately 75%. Thus, recommending maximum replacement and utilizing daylight as much as possible during the day for lighting, as well as implementing motion sensor-based lighting systems, are necessary to achieve energy savings without significant individual effort [6].

Furthermore, adopting measures such as minimizing computer usage, automatic power shutdown that are not in use, actively using standby power reduction programs, utilizing energy-saving modes, and installation of sensors to ensure that lighting in spaces that are not continuously used, such as locker rooms, are activated only when in use should be appropriately adapted from existing strategies employed in households and other industries to be applied uniformly in dialysis rooms.

Reducing the use of energy derived from high carbon emission sources such as oil and coal, and increasing the utilization of clean energy or renewable energy sources with lower carbon dioxide emissions, such as solar and hydro power, is one of the crucial efforts to mitigate greenhouse gas emissions. In fact, global efforts to maximize the use of such renewable energy sources are accelerating. However, as of 2018, the proportion of clean energy use in South Korea was around 40.6%, which is relatively lower compared to other advanced countries such as the UK (54.8%) and Germany (54.9%) during the same period. Therefore, it may be worthwhile to consider further active utilization of renewable energy [7].

When installing facilities for solar power generation, the reduction in carbon dioxide equivalent emissions can vary depending on the size of the solar power generation system, but it is estimated to be around 1.5 tons per year per 1 kW of installed capacity. According to a study by Agar et al., installing a 3 kWh solar power generation facility in a dialysis room can reduce power consumption by 91%. Because solar prices have plummeted, the payback period for the investment cost about the facilities could be markedly reduced, and there is no additional cost for further solar power generation afterwards. Moreover, the cost of electricity generation facilities of renewable energy is becoming affordable over time. Additionally, alternatives such as geothermal or biomass power generation for heating could be explored. However, feasibility may vary depending on the region in Korea, so proactive consideration of renewable energy usage could be made where such generation methods are feasible [8].

Most dialysis rooms in South Korea are often operated in rented commercial buildings, making it difficult to actively utilize rooftops compared to countries like Australia or New Zealand. Despite these limitations, it is necessary to actively encourage the utilization of clean energy and renewable energy sources in dialysis rooms where available.

Statements

When installing hemodialysis facilities and related electronic devices in a dialysis room, efforts should be made to establish and follow guidelines to actively encourage the increased use of low-power and f high-efficiency equipment, and reduce unnecessary use. Efforts to promote the use of renewable energy for dialysis treatment should be continued. Further efforts will be needed to support this movement through government policies and support.

Key Messages

3.2 We encourage all members of the Hemodialysis unit to actively participate together in energy-saving.

3.2.1 Corporations: Strive to develop additional optimization models for existing dialysis equipment to maximize energy efficiency.

3.2.2 Academic societies and governments: Propose standardized guidelines to promote the design and use of energy-efficient dialysis rooms and the use of Eco-Reporting Systems.

3.2.3 Consider including education on energy conservation and carbon neutrality in patient and staff education programs to spread environmental conservation culture and change individuals' environmental awareness.

Current Issues

For achieving Green Nephrology, not only are the efforts from healthcare professionals important, but also the attention and commitment from companies manufacturing dialysis machines are absolutely crucial, as the majority of energy consumed during dialysis occurs through these machines.

Manufacturers have put a lot of efforts to improve the technologies, reducing the dialysate usage by 30% compared to conventional machines through the application of the special priming techniques that can reduce annual water usage by 11,500 k (5008S, 6008S vs 408H dialysis machines). They have also continued efforts such as designing folding systems to increase the efficiency of delivery/disposal of tubes and consumables and making lightweight improvements to packaging. Furthermore, they are constantly developing improvement measures by redesigning the waterway inside the dialysis machines to ensure efficient heat exchange, thus maximizing the utilization of energy generated during dialysis.

Healthcare professionals should prioritize selecting dialysis machines that maximize energy efficiency, encouraging dialysis manufacturers to maintain continuous interest and participation in eco-dialysis.

Since 2005, France has implemented an Eco-Reporting System, tracking and observing Key Performance Indicators (KPIs) such as electricity and water usage, as well as the amount of waste generated from dialysis treatments, over a period of approximately 15 years. During this time, electricity consumption decreased by 29.6% (from 23.1 kWh/session to 16.26 kWh/session), while water usage decreased by 52% (from 801 L/

session to 382 L/session). The majority of these reductions were achieved through continuous remodeling of dialysis machines and water-related systems due to advancements in dialysis technology. Waste generated after dialysis decreased from 1.8 kg to 1.1 kg, attributed to education among healthcare professionals. Ultimately, it was reported that carbon dioxide emissions decreased significantly, totaling 102,440 tons, demonstrating the effectiveness of implementing Eco-Reporting as KPIs in dialysis rooms [8].

In Australia and New Zealand, guidelines were developed and distributed in 2022 to establish environmentally sustainable dialysis rooms, containing various recommendations for electricity usage and water purification systems. It is an informative guideline for medical staff performing Hemodialysis to refer to in the preparation, management, and treatment process and it is expected that there will be an evaluation of the practical effects.

It is expected that the education of medical staff performing dialysis treatment will also contribute to reducing and efficiently using the energy in the treatment process. The United Nations Framework Convention on Climate Change (UNFCCC) in 1992 mentioned that "Education is a crucial element for appropriate global responses to climate change [9]." While solutions to climate change and carbon emissions are primarily focused on strategies to reduce actual carbon emissions, it is essential to have citizens educated about climate change and environmental issues to successfully implement these strategies [9]. In fact, when evaluating the long-term impact of individuals' carbon emissions after receiving education on climate change and the environment, it was confirmed that the carbon emissions of educated individuals decreased by 2.86 tons annually [10]. Furthermore, when investigating the most effective methods to significantly reduce carbon emissions by 2050, education on climate change was reported to be the second most effective method after utilizing solar energy, surpassing methods such as afforestation, offshore wind power utilization, electric vehicle usage, building insulation, and LED lighting. This suggests that education has great potential for reducing carbon emissions [11]. Especially amidst the global trend of increasing numbers of dialysis patients and healthcare professionals involved in dialysis, raising awareness about the environment and considering education as one of the important measures to actually reduce carbon emissions should be emphasized.

Statements

In order to reduce energy consumption in the dialysis treatment process, it is necessary to increase the efficiency of dialysis devices through the efforts of manufacturers, institutionalize and manage systems that measure and report energy in the treatment process, and recognize and manage the necessity of energy management and the importance of reducing carbon emissions through education of medical staff participating in treatment.

Future Perspectives

As of now, there has been no specific statistics of the energy usage status during dialysis procedures, so it is essential to first understand the current situation. Additionally, there has been no research conducted domestically on the effects of implementing various energy-saving measures. It will be necessary to conduct investigations to determine the actual reduction in energy usage and carbon dioxide emissions when efforts to reduce energy consumption are made in the future. Tasks to verify the carbon footprint will be required. Practical and institutional considerations regarding the feasibility of converting dialysis room facilities to eco-friendly facilities are also necessary. In other words, it is necessary to consider establishing standardized Korean guidelines and regulations for Green Nephrology, introduce the Eco-Reporting System in the KPI, which is being tested in other countries, and enact guidelines for dialysis rooms to lead sustainable dialysis in dialysis rooms in Korea.

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Chapter 4
The Recommendations for Carbon Footprint Reduction in Hemodialysis

Key Message

4.1 In order to reduce the carbon footprint in the process of hemodialysis treatment, active consideration should be given to utilizing renewable energy sources.

Current Issues

It is estimated that each session of hemodialysis consumes 12-19 kWh of electricity, and significant power is also used in the reverse osmosis process for water purification, involving pumps and heat disinfection. The carbon footprint associated with this electricity usage remains a persistent issue. The predicted amount of carbon footprint varies depending on the region, with regions utilizing alternative energy sources showing lower carbon footprints compared to those relying on fossil fuels for power generation.

Statements

Efforts should be made to promote the use of renewable energy sources for the electricity consumed in hemodialysis treatment. Additionally, governmental policies and support should be sought to back up these efforts. encourage the participation of more patients and healthcare professionals.

Key Message

4.2 We propose to educate patients and medical staff to actively utilize public transportation.

Current Issues

Given that Hemodialysis treatment typically requires three sessions a week, the transportation of patients to and from the hospital during these sessions may contribute to ongoing emission-related issues. While data on transportation emissions in domestic settings have not yet been provided, it is anticipated that as such data accumulate in the future, the associated burdens may become apparent, leading to efforts aimed at effective reduction.

Statements

Efforts should be made to encourage the use of public transportation by patients and healthcare professionals during the process of traveling to and from treatment sessions. Promotion and enhancement strategies should be implemented to raise awareness of the importance of this initiative and to encourage the participation of more patients and healthcare professionals.

Future Perspectives

Research may be needed to explore methods for reducing the carbon footprint depending on the method of Hemodialysis. A small-scale comparative study conducted in the UK in 2007 suggested that Home

Hemodialysis could reduce carbon footprint compared to Facility based Hemodialysis (0.207 vs. 1.404 tons of CO_2 Eq patient per year).

However, most of the difference was calculated as emissions saved from patient transportation, necessitating a more precise comparison of water, energy, and waste usage to accurately measure the benefits or losses.

Further research is necessary to precisely assess the impact of Home Hemodialysis on energy consumption, since Home Hemodialysis is increasing in other countries and can be an option that can be introduced in Korea as well.

Additionally, efforts to minimize transportation distance may be necessary, such as promoting minimum transportation distance treatment facilities through network activation, utilizing shared vehicles, or enhancing home-based treatments, particularly in areas with long transportation distances.

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Peritoneal Dialysis

Peritoneal Dialysis Key Messages

5.1 It is recommended to actively consider methods for more efficient use of water resources in the production process of Peritoneal Dialysis fluid.

5.2 It is suggested to actively seek solutions to prevent the wastage of dialysate during the Peritoneal Dialysis treatment process in order to use water resources more efficiently.

6.1 Efforts are needed to reduce the environmental impact of Peritoneal Dialysis (PD).

6.1.1 To minimize the use of PVC in the manufacture of PD bags, it is proposed that dialysis bags should be made from PVC-free biodegradable materials wherever possible.

6.1.2 To increase the recycle rate of PD bags made of PVC, it is proposed that dialysis bags should be re-collected through a PD bag collecting system.

6.2 Shipping boxes used for Peritoneal Dialysis (PD) bag delivery should be made of paper and should be disposed of in a paper recycling bin.

7.1 To reduce the carbon footprint associated with emissions during the transportation process of Peritoneal Dialysis fluid, it is imperative to actively consider methods to minimize transportation.

7.2 Continuous efforts should be made to enhance the efficiency of the transportation process of Peritoneal Dialysis fluid, and actively considering of the use of environmentally friendly vehicles during transportation is essential

Chapter 5
The Recommendations for Water Conservation in Peritoneal Dialysis

Key Message

5.1 It is recommended to actively consider methods for more efficient use of water resources in the production process of Peritoneal Dialysis fluid.

Current Issues

Peritoneal Dialysis offers a more efficient use of water resources compared to Hemodialysis due to its lower volume of dialysate utilized in treatment. While Hemodialysis may consume around 360 liters of water per week with sessions lasting 4 hours, three times a week at a flow rate of 500 ml/min, Peritoneal Dialysis typically utilizes only 70 liters per week with a daily usage of 10 liters. Dialysate for peritoneal dialysis treatment is produced with complex process with chlorination to kill bacteria and other microbes, multimedia filtration to remove sediment and particulates, applying softener to remove hardness (calcium and magnesium ions), and carbon filtration to remove odor, taste, chlorine.

However, similar to Hemodialysis, Reverse Osmosis (RO) process is applied for the final step before distillation, and it is associated with generation of reject water, although the percentage of wastage is much lower than the RO process of individual hemodialysis unit. Hence, methods to minimize this consumption should be considered.

Statements

In the production and processing of Peritoneal Dialysis fluid it is essential to use water resources more efficiently. Enhancing the efficiency of membranes in the RO process, similar to what is done in Hemodialysis, is necessary to reduce Reject Water. Additionally, strategies for reprocessing and reusing Reject Water for other purposes need to be developed.

Since Peritoneal Dialysis fluid production systems typically operate multiple and concentrated production lines, it might be more effective to collect Reject Water and utilize it for different purposes rather than processing it individually in each unit. Potential uses for Reject Water include industrial or agricultural purposes, or even reuse within the facilities producing Peritoneal Dialysis fluid for activities such as flushing toilets, tap water, or landscaping.

Key Message

5.2 It is suggested to actively seek solutions to prevent the wastage of dialysate during the Peritoneal Dialysis treatment process in order to use water resources more efficiently.

Current Issues

In Peritoneal Dialysis, the amount of dialysate required varies depending on the patient's residual renal function and body weight. Currently, only one standard volume of dialysate is provided for each method, Continuous Ambulatory Peritoneal Dialysis (CAPD) and Automated Peritoneal Dialysis (APD) usign various volume of dialysate depending on each patient may lead to significant wastage of dialysate after each treatment session under fixed volume of dialysate unit. Therefore, it is deemed necessary to diversify the volumes of Peritoneal Dialysis fluid provided to reduce the wastage of water resources.

Additionally, it is estimated that 180 liters of water are used to manufacture 1 kilogram of plastic bags. Since the weight of Peritoneal Dialysis fluid bags is approximately 155 grams, the additional water usage due to plastic usage should be calculated based on the number of bags used per day (3~5 bags/day), resulting in 84~140 liters of additional water usage per day. Hence, reducing the number of plastic bags used can also aid in conserving water resources.

In Korea, while Peritoneal Dialysis fluid falls under special insurance coverage, with only a 10% patient copayment. However, drainage bags are classified as medical materials and are not covered by dialysis reimbursement, leading to higher patient copayments for drainage bags compared to Peritoneal Dialysis fluid bags. Therefore, while it would be ideal to use only drainage bags in cases requiring drainage without using the connected dialysate, such as Night Intermittent Peritoneal Dialysis (NIPD) and other treatments, the current medical environment leads to the wastage of water resources due to the disposal of connected dialysate along with the drainage bags.

Statements

To ensure efficient use of water resources in Peritoneal Dialysis treatment, it is necessary to eliminate the wastage of dialysate after treatment sessions. Therefore, diversifying the packaging units of Peritoneal Dialysis fluid to enable maintenance of dialysis treatment without the disposal of dialysate for each patient is essential. Additionally, applying medical insurance to drainage bags for actual use in treatment settings is crucial to prevent unnecessary wastage of Peritoneal Dialysis fluid.

Future Perspectives

In the future, it is thought to be necessary to actively pursue the development of highly efficient pure water production systems, such as Vapor Compression Distillation, in addition to the current Reverse Osmosis (RO) systems. Vapor Compression Distillation is a method commonly used for desalination, producing pure water by removing mineral salts, similar in principle to RO systems. Therefore, efforts should be directed towards the design of such high-efficiency pure water production systems.

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Chapter 6
The Recommendations for
Waste Reduction in Peritoneal Dialysis

Key Messages

6.1 Efforts are needed to reduce the environmental impact of Peritoneal Dialysis (PD).

6.1.1 To minimize the use of PVC in the manufacture of PD bags, it is proposed that dialysis bags should be made from PVC-free biodegradable materials wherever possible.

6.1.2 To increase the recycling rate in PD bags, we propose the vitalization of recollecting the bags through a dialysate delivery system.

Current Issues

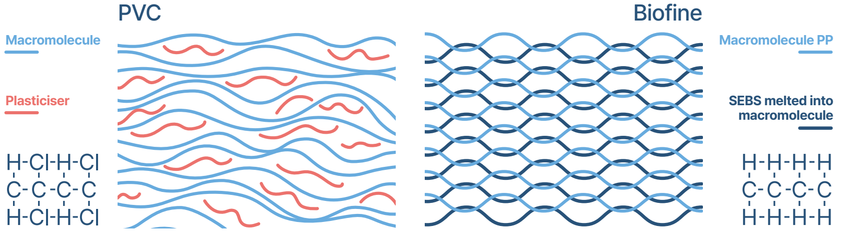
Compared to Hemodialysis (HD), Peritoneal Dialysis (PD) is thought to produce less waste per dialysis session than HD, but because it is performed every day, the total amount of waste is reported to be slightly higher for PD than for HD when calculated per patient per year. In addition, for PD, -a significant portion of the carbon emission arises from the packaging of dialysis fluid, the manufacture of plastic dialysis bags, as well as the transportation process involved in delivering the PD solution to individual homes. So efforts to minimize these processes are urgent.

According to data from the Korea Environment Corporation, PVC is known to release dioxins and long-term pollutants into the air and soil during the manufacturing process, and to emit dioxins and heavy metals when landfilled or incinerated., Greenpeace classifies PVC as the most harmful plastic and is trying to suppress its use. Therefore, there is an urgent need to manufacture dialysis bags using PVC-free, biodegradable materials as much as possible. In cases where PCV bags are used, it is crucial to ensure proper collection for recycling.

- Biofine® material currently used in PD does not contain chlorine, it has the advantage that it does not produce any environmentally harmful substances when incinerated (Figure 1). However, due to a lack of sufficient data, further studies are needed to assess the environmental impact of Biofine.

- A comparison of current Biofine-based products with PVC-based products showed that up to 88 kg of disposable waste could be saved per year for CAPD patients and up to 29 kg for APD patients.

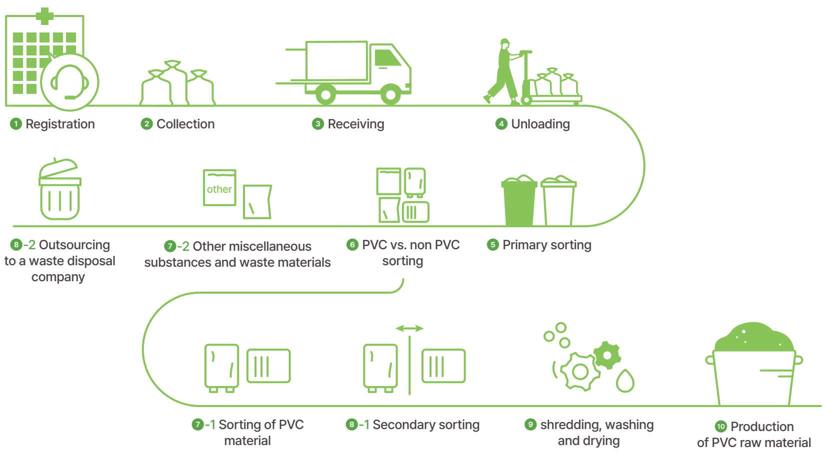
- Another Peritoneal Dialysis company is also working on permits, aiming for using non-PVC materials in Korea in the late 2025 to early 2026, so it is expected that green evolution will continue.



[Figure 1]

- Even if the materials are recyclable, it is expected that collecting only dialysis bags, a single recyclable material, will greatly increase the efficiency of recycling, rather than mixing them with other household waste. Currently a Korean PD company collects all PVC material dialysis bags, recycles those that can be recycled through a process, and reduces those that cannot be recycled to a minimum and disposes of them.

- The collection and processing process is shown in the picture below(Figure 2). First, the PVC bags are manually sorted (primary sorting). PVC bags are soft and flexible, so unlike other packaging materials which are hard and rigid, they can be made into raw materials and reused. After secondary sorting, the PVC bags are mechanized in the order of shredding, washing and drying, then pulverized and reused as PVC raw materials. This process currently recycles more than 87% of post-sorted PVC bags in Korea. The amount recycled annually is confirmed to be more than 250,000 kg. However, this process is currently only available in the metropolitan area, South, North Gyeongsang and Youngnam regions. It would be necessary to expand the process nationwide.



[Figure 2]

Statements

It is necessary to increase the utilization of environmentally friendly materials throughout treatment, including the use of biodegradable bags, and to increase the recycling rate by collecting used Peritoneal Dialysis bags.

Key Message

6.2 Shipping boxes used for Peritoneal Dialysis (PD) bag delivery should be made of paper and should be disposed of in a paper recycling bin.

Current Status

When delivering Peritoneal Dialysis fluid in other countries, the packaging box contains filling materials such as vinyl or wool to prevent damage, making it difficult to recycle. Currently in Korea, all packaging boxes are made of paper and no filling material is used inside the box, making it 100% recyclable when patients separate and dispose of it properly. It is important to continue the use of these stable delivery systems and recycled materials.

Future Perspectives

There is still a lack of data comparing the amount of waste by PD method (CAPD, APD, CCPD). According to the available data, the use of Disinfection caps is reduced when Automated PD (APD) is used with an APD machine (4 caps to 1 cap) compared to CAPD, which is changed 4 times a day, but additional use of the Tubing system and Drainage set is required with APD or CCPD. In addition, the use of the machine is expected to result in additional electricity consumption.

Therefore, in the case of APD/CCPD, it is currently worth considering reducing the amount of dialysate used, if possible, as a way of reducing PD-related waste. In this regard, Incremental PD should be considered among patients with good residual renal function. Future research is needed to compare and analyze the amount of waste, annual processing costs and carbon footprints between Incremental PD and standard PD.

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Chapter 7
The Recommendations for
Carbon Footprint Reduction in Peritoneal Dialysis

Key Message

7.1 To reduce the carbon footprint associated with emissions during the transportation process of Peritoneal Dialysis fluid, it is imperative to actively consider methods to minimize transportation.

Current Issues

In the case of Peritoneal Dialysis, the amount of carbon footprint generated during the dialysis treatment process is estimated to be relatively low compared to Hemodialysis. Although there may be differences depending on the country and the method of calculation, in the case of carbon footprint estimated for Hemodialysis treatment, it has been reported as 3.8 tons CO_2-Equivalent (CO_2-Eq) per patient annually in the UK, and 9.18 tons CO_2-Eq in the United States. The main reason for regional differences is believed to be the variance in the distance traveled by patients and medical staff to the dialysis treatment facility, which is the hospital. According to Australian research, it has been reported that an individual's carbon footprint prediction is 10.2 tons CO_2-Eq per year, which has increased due to the inclusion of medication effects, making it a valuable resource for accurately understanding the impact of Hemodialysis treatment.

Compared to hemodialysis, research on the carbon footprint of peritoneal dialysis has not been actively conducted. A study reported from China estimates an annual carbon footprint emission of 1.4 tons CO_2-Eq per person. However, this study had limitations in accurately calculating the transportation of dialysis bags. Therefore, it is believed that the main factors contributing to the carbon footprint in Peritoneal Dialysis treatment are emissions generated during the transportation of dialysis fluid and accessories required for the treatment. Improvement in addressing the carbon footprint related to these factors is necessary. Recent study from Australia, MacAlister et al reported that the annual CO_2-Eq per person for Peritoneal dialysis treatment was much lower compared to Hemodialysis treatment. Considering variation of transport impact depending the distance, it was estimated 1,455-2,716 kg in CAPD, while APD was higher as 2,350-4,503 kg.

Transporting Peritoneal Dialysis fluid through maritime routes is estimated to generate 1 ton CO_2-Eq annually for every 1000 km transported per patient. Similarly, transportation via land routes results in an increase in carbon footprint proportionate to the distance traveled. According to data released in Australia, if a patient receiving treatment in Perth receives delivery from Sydney (4000 km), an estimated 3.1 tons CO_2-Eq is generated from the daily delivery alone.

Statements

Although carbon emission from Peritoneal dialysis treatment is calculated lower compared to those of Hemodialysis treatment, effort for reducing the amount should be continued. Along with reducing and recycling the waste product during Peritoneal dialysis treatment, various effort to modify the impact from transportation process should be considered.

Key Message

7.2 Continuous efforts should be made to enhance the efficiency of the transportation process of Peritoneal Dialysis fluid, and actively considering of the use of environmentally friendly vehicles during transportation is essential

Current Issues

In the current process of Peritoneal Dialysis treatment, aside from overseas transportation, the carbon footprint generated in the process of delivering Peritoneal Dialysis fluid and consumables to each household for treatment can be a significant concern. Domestic transportation of Peritoneal Dialysis fluid is managed through contracts between dialysis companies and specific delivery services. Efforts are made annually by analyzing various factors such as patient ratios and delivery volumes to minimize routes and optimize delivery systems by scheduling deliveries based on geographical locations, aiming to maintain maximum efficiency.

Statements

In the future, continuous discussions should focus on minimizing travel routes while minimizing patient inconvenience in the delivery process of

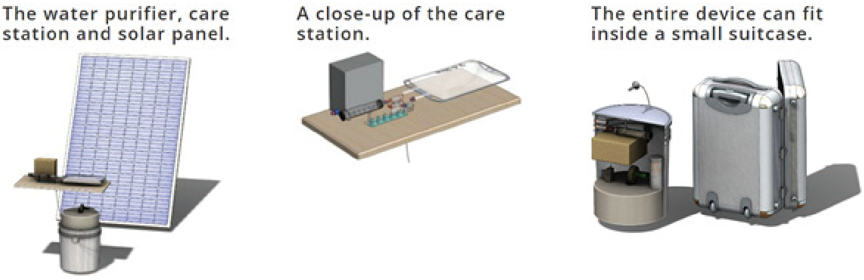
Peritoneal Dialysis fluid. Introducing regional logistics centers or similar facilities could also be considered to streamline delivery units more efficiently.

Additionally, efforts should be made to minimize emissions from vehicles transporting Peritoneal Dialysis fluid by introducing systems utilizing natural gas or electric vehicles.

Future Perspectives

The introduction of a system where Peritoneal Dialysis fluid is produced in individual households could help enhance the efficiency of water resource usage and reduce emissions associated with transportation.

In Australia, ongoing clinical research by Ellen Medical Device is exploring the use of a vaporization principle to distill tap water into purified distilled water directly in each household. This is a method introduced in World Kidney Day after receiving the Affordable Dialysis Prize in 2016. This method involves using a small-scale vaporization device powered by solar energy to produce pure water, which is then collected in sterilized bags and mixed with electrolytes and glucose powder to create Peritoneal Dialysis fluid. The prototype is currently being upgraded, and Pilot studies are underway in actual households to assess the suitability of the produced dialysis fluid. If successful, this innovation could play a crucial role in resource conservation and reducing carbon footprint in Peritoneal Dialysis treatments upon commercialization.


The water purifier, care station and solar panel.
A close-up of the care station.
The entire device can fit inside a small suitcase.

[Figure 1]

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Continuous Kidney Replacement Therapy

Chapter 8 The Recommendation for Water Conservation in Continuous Kidney Replacement Therapy

Chapter 9 The Recommendations for Waste Reduction in Continuous Kidney Replacement Therapy

Chapter 10 The Recommendations for Energy Saving for Continuous Kidney Replacement Therapy

Continuous Kidney Replacement Therapy Key Messages

8.1 We recommend each institution to monitor the dose of dialysis delivered so that the delivered dose can be maintained between 20~25 mL/kg/hr.

9.1 We suggest avoiding routine replacement of the filter membrane every 24 hours in the absence of membrane failure.

9.2 We suggest every institute to implement separated disposal of the recyclable waste (packaging materials, support plate, dialysate bag) and every manufacture to consider active recycle of the waste.

9.3 We suggest the use of Regional Citrate Anticoagulation to increase filter life and reduce filter waste.

10.1 We recommend making active efforts for reducing repetitive priming by avoiding unnecessary interruptions in Continuous Kidney Replacement Therapy (CKRT).

Chapter 8
The Recommendation for Water Conservation in Continuous Kidney Replacement Therapy

Key Message

8.1 We recommend each institution to monitor the dose of dialysis delivered so that the delivered dose can be maintained between 20~25 mL/kg/hr.

Current Issues

According to the reports by Rhee [1] and Lee [2], the usual prescribed and delivered doses for Continuous Kidney Replacement Therapy (CKRT) in South Korea are between 35~40 mL/kg/hr and the actual dose delivered ranges from 30~40 mL/kg/hr, which implies more than 90% of prescribed doses are delivered. In the implementation of CKRT, prescription of unnecessarily higher dose than required leads to the unnecessary increase in water usages (Dialysate fluid, Replacement fluid).

Previous randomized controlled trials (ATN trial [3], RENAL trial [4]) clearly showed that CKRT dose higher than 20~25 mL/kg/hr did not decrease mortality as compared with less-intensive therapy. Based on that, current Kidney Disease Improving Global Outcomes (KDIGO) acute kidney injury (AKI) guideline 2012 recommends delivering an effluent volume of 20~25 mL/kg/hr for CKRT in AKI (evidence level 1A) [5] However, when applying CKRT in clinical settings, it is stated that a higher dialysis dose can be prescribed because the Down time, which is the time to stop CKRT due to various reasons (transfer, examination, filter replacement, etc.) [5].

One center in South Korea shared their Quality Improvement (QI) experience on CKRT dosing; Before QI, usual prescription dose was between 30~35 mL/kg/hr, a mean delivered dose was 31.1 mL/kg/hr (89 to 90%) and their mean amount of dialysate expenditure was 53.6L/day/person. During the QI, prescription dose was reduced down to 25~30 mL/kg/hr, mean delivered dose was 27.4 mL/kg/hr and the mean dialysate expenditure was reduced by 6.8L/day/person.

Statements

It is estimated that, nearly two-folds higher doses than recommended are prescribed in South Korea. As unnecessarily higher doses lead to increase of water waste as well as the increase of carbon footprint for purification of dialysate, packaging, and delivery, we recommend every institution that provides CKRT measure actually delivered dose and modulate the dose prescription to maintain the adequate delivered dose.

Chapter 9
The Recommendations for Waste Reduction in Continuous Kidney Replacement Therapy

Key Message

9.1 We suggest avoiding routine replacement of the filter membrane every 24 hours in the absence of membrane failure.

Current Issues

Korean National Insurance system covers one filter per day, and estimated mean Continuous Kidney Replacement Therapy (CKRT) filter life is 23~24 hours (estimated by the Korean Health Insurance Review and Assessment (HIRA) data base; total number of filters used/ total frequency of CKRT procedure-claimed) in South Korea. In most centers, filter membrane is replaced depending on the changes in Transmembrane Pressure (signs of impending filter clotting), meanwhile, in some other centers, filter membrane is routinely replaced to the new one every 24 hours, even in the absence of membrane failure, based on the upper limit of national insurance coverage.

Statements

According to the CKRT Dialysis Membrane Kit Import Permit, the replacement of filter membrane is proposed once every 24 hours and it also recommends discarding the filter after 72 hours of operation [6]. Nevertheless, average filter life outside of South Korea is usually over 35 hours, and Acute Disease Quality Initiative (ADQI) group suggest maintaining of filter life more than 60 hours at least 60% of the filters used in each institute [7]. Based on that, we suggest avoiding routine replacement of the filter membrane every 24 hours in the absence of membrane failure so that we can reduce plastic waste (membrane, blood tubes, packaging materials, support plate, etc.), and carbon footprint associated with filter membrane.

Key Message

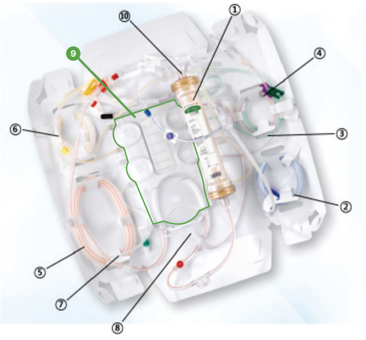
9.2 We suggest every institute to implement separated disposal of the recyclable waste (packaging materials, support plate, dialysate bag) and every manufacture to consider active recycle of the waste.

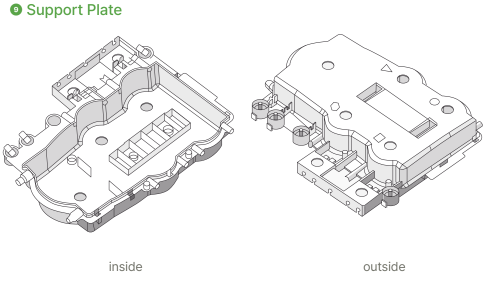
Current Issues

Implementation of CKRT generates huge amounts of medical waste, in which includes not only blood-contaminated filter membranes and tubes connected to the filter but also support plate and the dialysate bags that are not contaminated by blood [Figure 1]. This means that hazardous (infectious) waste and general waste are mixed. If strict and user-friendly guidelines for separation is not applied, even recyclable waste will be handled as hazardous waste, increasing the amount and processing cost of hazardous waste that need special treatment.

CKRT filter-kit is composed of filter membrane, tubes connecting the filter, supporting plate, and their packaging. Although the weight varies depending on the surface area of the membrane or its manufacturer, it weighs 772~920 g in general, of which contains various types of plastic; polyethylene, polycarbonate, polyurethane, and polyvinyl chloride. Among them, supporting plate, which is polyethylene terephthalate, weighs 209 g, nearly 22~27% of the kit. Since it is not directly contacted to the patient's blood or discharge, recycling of the waste might be possible once it is disposed separately.

An empty bag of dialysate or replacement solution composed of pure polyolefin, with which weighs approximately 62 (5 L bag) to 76 (10 L bag) g. Previous research reports that this is suitable for high quality recycling, since it is a clean waste that can be separated easily from other waste[8]. The Connectors the bottom of the bag have to be removed because they consist of a different type of plastic, unsuitable for this type of recycling.





1	Hemofilter/Dialyzer(①)	Connected to each circuit to remove waste from circulating blood.
2	Blood return line(②)	Reinjects filtered blood into the patient.
	Dialysate injection line(③)	Connects dialysate and dialysis machine.
	Replacement solution line(④)	A connecting circuit when injecting replacement solution.
	Blood access line(⑤)	Connects blood from a patient to a dialyzer for extracorporeal circulation.
	Used dialysate release line(⑥)	Connected to a 5-liter bag and dialyzer to release the used solution after dialysis.
2	Pre-Blood Pump line(⑦)	A circuit used to inject additional dialysate from the patient access circuit prior to the blood pump.
	Anticoagulation line(⑧)	A circuit to delay blood clogging by coagulation.
3	Supporting plate(⑨)	Effectively retains the product set.
4	Screw connecter(⑩)	The area where the circuit is connected at both ends of the filter.

Figure 1 CKRT filter-kit components

Future Perspectives

National level efforts need to be paid to refine regulations on the medical waste management to make potentially recyclable wastes to be properly recycled.

Key Message

9.3 We suggest the use of Regional Citrate Anticoagulation to increase filter life and reduce filter waste.

Current Issues

According to the data from the Korean HIRA service, a total of 13,841 patients were received CKRT in 2022, with the usages of 104,631 of filter membrane, which corresponds to the usage of approximately 7~8 numbers of filter membrane per each CKRT session. Based on the frequency of CKRT procedure code in the HIRA system (122,595 in 2022), the mean estimated duration of CKRT is 8 to 9 days, and the filter life as 23~24 hours, which is significantly shorter than those reported in the study of Zarbock et al. (filter life 35~42 hours) with Regional Citrate Anticoagulation [9].

Statements

Regional Citrate Anticoagulation is the KDIGO-recommended method for CKRT anticoagulation, which increases the life span of filters without the risk of bleeding. In other countries, this method is mainly used in CKRT. Compared to the filter life with Regional Citrate Anticoagulation, estimated filter usage per each CKRT session is nearly 1.5 to 1.8 times higher in South Korea, which leads to the increase in filter waste. If Regional Citrate Anticoagulation become available in South Korea, nearly 30~45% of reduction of waste is anticipated in filter membrane.

Future Perspectives

National level efforts should be made for the Regional Citrate Anticoagulation to be available for CKRT in South Korea.

Chapter 10
The Recommendations for Energy Saving for Continuous Kidney Replacement Therapy

Key Message

10.1 We recommend making active efforts for reducing repetitive priming by avoiding unnecessary interruptions in Continuous Kidney Replacement Therapy (CKRT).

Statements

The power consumption for CKRT priming is 33% higher compared to the energy consumption during CKRT operation (average of 120 W per hour during priming versus 90 W per hour during operation, [Figure 1]).

During priming   During operation

Figure 1 Actual measurement results of energy consumption during CKRT procedures

If the frequency of filter changes increases, not only does the consumption of CKRT filter kits rise, but also the frequency of priming procedures increases, leading to a corresponding rise in energy consumption. The reasons for interruptions and subsequent priming during CKRT are diverse. According to reports by Rhee et al., the most common causes for membrane change were not related to filter problems; transfers for examinations, procedures, and surgeries, accounting for 50.8%, while exchanges due to filter clotting constituted 19.9% [10].

Statements

To reduce the repetitive priming performed due to filter clotting, we propose the introduction of Regional Citrate Anticoagulation. Additionally, we recommend pre-adjusting patient movements and examination schedules within reasonable limits before initiating CKRT.

Future Perspectives

In the future, it is essential to enhance the performance of CKRT machines by maximizing the energy storage capacity within the device. This improvement aims to facilitate ease of mobility for a relatively extended period without connecting to a power source.

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