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The Impact of Reuse Dialyzer Application on Routine Hemodialysis Patients Adequacy and Its Correlation with Cost Efficiency in Type D Hospital

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Abstract

Introduction: Hemodialysis (HD) is one of the high-cost service units in the hospital that implemented the cost efficiency policy by applying a reuse dialyzer. According to a claim received from National Health Insurance (JKN) system, the HD procedure for type D hospitals received the smallest claim payment if it compared to type A, B, and C hospitals. The policy of reuse dialyzer application will be measured its effect on the effectiveness of Ureum Reduction Ratio (URR) and Kt/V as adequacy values. Also, it associated with cost efficiency in type D hospital settings. The aims of this study were to 1.) measure the correlation between the policy of reuse dialyzer application and the HD adequacy value and 2.) evaluate the cost efficiency policy that implemented by type D hospital HD unit in the form of using reuse dialyzer.

Methods: The study was conducted with a cross-sectional design study from the data of URR and Kt/V on routine HD patients at four types of D hospitals in Yogyakarta and Central Java, Indonesia in January-March 2021. HD adequacy values were compared between the groups using the new and reuse dialyzers. Cost efficiency was calculated based on the differences of cost between the cost of the HD procedure using a reuse dialyzer and the projected cost if it is carried out with a single-use dialyzer.

Results: The HD adequacy data were obtained from 112 subjects consisting of 22 with a new dialyzer, 32 using reuse dialyzer (R) dialyzer first(R1) and R2, 27 with R3-R4, and 31 with R5-R7. The analysis of using reuse dialyzer on URR and Kt/V in the group with new and reuse dialyzers was obtained $p = 0.90$ and 0.91. The HD adequacy value in using reuse dialyzers was not significantly different from using the new dialyzer. The result of the cost efficiency analysis was 20.55% with using a reuse dialyzer when it is associated with a source of income for HD services in type D hospitals.

Conclusion: There is no difference in HD adequacy between the new and reuse dialyzer. The dialyzer reuse is less costly 20.55% compared to the new one in type D hospital.

Keywords: Hemodialysis, reuse dialyzer, HD adequacy, efficiency

1. Introduction

The hemodialysis Unit (HD) is one of the high-cost service units in the hospital. The procedure is mainly given to patients with chronic kidney disease (CKD) who require renal replacement therapy. The numbers of CKD that requires renal replacement therapy is quite high as in Indonesia, there was a significant increasing of cases of CKD in 2018 compared to 2017 (1). Hence, when it multiplied by high cost, the HD unit becomes one of the units with great financial potential in the hospitals.

HD services in Indonesia are guaranteed by the National Health Insurance (JKN) system. According to recorded data of 2018, 90% of patients uses JKN for HD financing (1). Although, the HD service standards do not have different in all service-providing facilities, the number of claims that paid by the JKN system is different for each type of hospital and service as if the hospitals with a larger type will get a larger number of claims. Then, it can be said that type D hospitals get the smallest claims compared to hospitals with types A, B, and C.

In addition, the quality of HD services can be measured in objectively based on the HD adequacy values in which it assessed from the Urea Reduction Ratio (URR) and Kt/V numbers in patients undergoing HD procedures (2). The HD adequacy value is used as a benchmark for the effectiveness of an HD procedure. An HD procedure with a frequency of two times in a week is adequate if it meets the URR and Kt/V values of >80% and >1.8 (3). HD service units of type D hospitals are required to perform cost-efficiently, but it still provides the services under established clinical service standards.

One of the forms of efficiency policy that was carried out in the HD unit is the use of an artificial kidney or dialyzer. Besides, The use of reuse dialyzers has also been proven to increase membrane biocompatibility. Also, it aims to reduce various side effects of HD treatment, the incidence of anaphylaxis, and symptoms of the first-use syndrome (4.5).

Based on the results of several studies, the use of reuse dialyzers is still controversial because it increases the possibility of infection and the emergence of complaints related to chemicals reused in the reprocessing process. Furthermore, it also can reduce patients' quality of life and increase hospitalization possibilities (6). The URR and Kt/V values as benchmarks of HD adequacy achievement, are also hypothesized to be influenced using reuse dialyzer because of the reduction in total cell volume (TCV) as the effect of the reprocessing process. As well, the inadequate HD is a major factor in increasing patient morbidity and mortality (7). According to the Hemodialysis (HEMO) Study Group data, there is a 1-2% decrease of urea clearance in every 10 times of the use of reuse dialyzer regardless of the type of dialyzer or the reprocessing technique used (5.8). From all the HD procedures in Indonesia, there is 47.48% using reuse dialyzer (1). Thus, it is essential to reevaluate the quality of HD services since the high rate of using reuse dialyzer in Indonesia.

According to several studies in developing countries, the use of reuse dialyzer can reduce costs between 32%-34.6%. As the result of the studies, it was calculated based on the reduced cost of buying a dialyzer and the incidence of hospitalization (9). Even though, The use of reuse dialyzer can reduce the amount of dialyzer usage and the financing for medical waste management but the reprocessing dialyzer provides additional costs such as electricity cost, water treatment, the dialyzer disinfectant liquid, and wages for officers who carries out the dialyzer reprocessing. In this study, the cost efficiency will be calculated based on the cost that distinguishes between the groups of using reuse dialyzer and single-use dialyzer. Also, The measurement of efficiency and its relation to service effectiveness are the consideration of clinical policies in the HD unit as a strategy in the type D hospitals.

2. Materials and Methods

The study was a cross-sectional study using secondary data as adequacy values of routine HD patients. The study was conducted in 4 types of D hospitals, including Condong Catur Hospital (RSCC) Sleman, Puri Husada Hospital (RSPH) Sleman, Nirmala Suri Hospital (RSNS) Sukoharjo, and Arafah Islamic Hospital (RSIA) Rembang. Additionally, the management of HD services in the four hospitals is in collaboration with the same medical eqiopment provider company, namely Masa Cipta Husada (PT MCH). Besides, the four hospitals are also used the same brand and type of medical devices and consumables.

The adequacy values in the study were the results of laboratory tests in Ureum Reduction Ratio (URR) and Kt/V in which it was routine adequacy examination programs for HD patients in the four hospitals. The adequacy examination program is a monthly routine examination program that scheduled every three months for a patient. As the result, This study was used total sampling by using all the data on HD adequacy of patients in the January-March 2021 examination period. The total research subjects that used in this study were 112 HD adequacy data of patients, consisting of 32 subjects from RSCC, 27 subjects from RSPH, 27 subjects from RSNS, and 26 participants from RSIA.

Adequacy data from all the research subjects were divided based on the type of dialyzers when the adequacy examination was carried out. The adequacy data were divided into four groups such as the group using the new dialyzer, the group using the first and second (R) dialyzer reuse (R1-R2), the 3rd and 4th reuse (R3-R4), and the 5th to 7th reuse (R5). -R7). Therefore, the average achievement of adequacy value from the four groups was compared and analyzed using the one-way ANOVA statistical test.

The analysis on the cost efficiency in this study was used financial data on the HD unit at RSCC Sleman in March 2021. The data was involved the services for 50 routine patients with 421 HD procedures. According to the cost-efficiency analysis, measurements were completed by finding the cost factors that differentiated between HD procedures using reuse dialyzer and single-use dialyzers. Finally, by calculating the different financing factors, it was found the difference in costs between the two groups.

The finance grouping of the reuse group and the single-use group were carried out based on the guidelines of Cost Analysis in Primary Health Care by Creese and Parker (10). Generally, the finance grouping was divided into capital costs and recurring costs. From the list of financing, it is assessed in which financing is the distinguishing factor. Additionally, a calculation was aimed to distinguish financing factors. The financing factor analysis was also completed based on the HD procedure movement. There were several different activities in the two groups, as a dialyzer reprocessing procedure and an increase in the volume of handling medical waste. The financing factors were calculated for the difference in costs for the group of using reuse dialyzers and single-use dialyzers. The difference was the value of cost efficiency that associated with the source of financing from JKN for HD services in the type D hospitals.

3. Results and Discussion

A. The Effects of Reuse Dialyzer Application on HD Adequacy

The Basic Characteristics of Research Subjects

The basic characteristics of the subjects in this study were divided into demographic characteristics, characteristics of comorbidities, and characteristics related to HD procedures. In this study, the number of male research subjects was 59.80%, with the average age of all research subjects was 54.49 ± 1.00 years (table 1). It was in line with the incidence of CKD sufferers in Indonesia which is covering 57% of men and 43% of women (1). In developed countries as the United States, the incidence of CKD is also higher in men than in women as 61.54% and 38.45% (11). In a previous study that measured the relationship between reuse dialyzer membranes with the Quality of life of routine HD patients, male research subjects were greater than women with the percentage of 57.6% and 42.4% (12).

The average age of the subjects in this study was in line to the incidence of CKD sufferers in Indonesia in which it continues to increase, especially at the age above 54 years. The highest was in the age range of 65-74 years with the percentage of 8.23‰ (13). In several previous studies related to routine hemodialysis patients, the average age of the research subjects was 43-59 years (9,12,14-18).

In this study, 70.50% of the subjects had comorbidities with HT, and the other 24.10% had comorbidities with DM. Several previous studies found that comorbidities were the highest in routine HD patients with HT at 94.8% and 76.9%, and DM at 44.7% and 19.8% (7.12). Based on the data in Indonesia, the highest comorbidities in patients with CKD with HT was 51%; then, the case followed by DM was 21%. The high rate of HT in patients with chronic kidney disease occurred because of the initial etiology of CKD. Then, HT generally occurred in these patients.

Based on table 1, it can be said that the history of undergoing HD in study subjects was 2.52 ± 0.16 years. The factors that could affect the length of HD history in research subjects were because of the two hospitals had provided HD services in the last five years. Then, most of the patients were new patients that diagnosed with CKD for less than five years.

In addition, as defined in table 1, the data on treated blood time, ultrafiltration (UF), quick blood (QB), and the type of dialyzer in the research subjects were compared to the HD profile data in Indonesia. The average value of the treated blood time was achieved ultrafiltration, and QB in the study subjects were 4.86 ± 0.02 hours, 2.55 ± 0.10 liters, and 240 ± 1.98 ccs/minute. The data are consistent with the profile of HD procedures in Indonesia, which is more than 60% of the total HD procedures that performed with a duration of more than 4 hours, with a QB of 200-249 cc/minute (1). According to Guidelines for Hemodialysis Adequacy 2015, it published by the Kidney Disease Outcomes Quality Initiative (KDOQI) in which it recommended HD duration of 3-5 hours for a frequency of 3 times a week (2).

Table 1. The Basic Characteristics of Research Subjects

Demographic Characteristics	Total (%)	Average (±SD)
Gender		
Men	67 (59.80%)	
Women	45 (40.20%)	
Subjects' age (year)		54.49 (±1.00)
Comorbidity Characteristics		
Hypertension (HT)	79 (70.50%)	
Diabetes Melitus (DM)	27(24.50%)	
Characteristics related to HD		
Length of history of undergoing HD (year)		2.52 ± 0.16
Treated Blood Time (hour)		4.86 ± 0.02
Achieved Ultrafiltration (liter)		2.55 ± 0.10
QB (cc/minutes)		240 ± 1.98
Blood pressure preHD		
< 140/90 mmHg	42 (37.50%)	
≥ 140/90 mmHg	70 (62.50%)	
Dialyzer Type		
New	22 (19.60%)	
R_1-R_2	32 (28.60%)	
R_3-R_4	27 (24.10%)	
R_5-R_7	31 (27.70%)	

Based on pre-HD blood pressure in all the subjects in this study, it is only 37.50% of patients had blood pressure under <140/90 mmHg. Another study in Palestine was measured an adequate HD dose. It found that 51.6% of all of the research subjects had pre-HD blood pressure <140/90 mmHg (19). Additionally, according to JNC8, the standard blood pressure in patients with CKD with or without DM was <140/90 mmHg (20). It also found that uncontrolled blood pressure was one of the complications because it increases the possibility of intradialytic complaints in patients. Hypertension is a major complication in HD procedures, then it makes the blood pressure monitoring since the beginning of the HD procedure is very important to control the emergence of intradialytic complaints.

Based on the type of dialyzer used, the highest adequacy data on the research subjects using 1-2 dialyzer reuse was 28.6% . Then it was followed by using the 5-7 reuse dialyzers with 27.7%, the 3-4 reuse dialyzers with 24,1%, and 19.6% of new dialyzers. However, Pernefri had recommended the use of reuse dialyzer up to a maximum of 7 reuses but in Indonesia, reuse of dializer was still carried out until it was reused more than 16 times. The highest proportion of dialyzer use in Indonesia was dialyzer reuse 1-5 times, 66 % (1).

The HD Adequacy Achievements in Research Subjects

The parameters that used to measure the adequacy of an HD procedure were the URR and Kt/V values. In this study, the distribution of research subjects based on URR and Kt/V could be seen in table 2. The average of URR for research subjects was 70.37 ± 11.011%. The lowest Ureum Reduction Ratio of the research subjects was 33.33%, and the highest was 100%. Based on the interval estimation, 95% of the research subjects had an average URR that were 68.31% to 72.43%.

Based on the distribution of the value Kt/V, it was obtained that the average Kt/V of all research subjects was 1.27 ± 0.363. The lowest value of Kt/V was 0.07, and the highest was 2.23. 95% of the research subjects that had an average Kt/V from the interval estimation results, distributed 1.20 to 1.34 (table 2).

Table 2. The Distribution of Research Subjects According to URR and Kt/V

	Mean	s.b.	Minimum-maximum	95% IK
URR	70.37	11.01	33.33-100,00	68.31 – 72.43
Kt/V	1.27	0.36	0.07-2.23	1.20 – 1.34

In several countries, the HD adequacy achievement was higher than the HD adequacy achievement. There were some informations related to the studies as study in Tanzania, the average value of URR was 60.9%, and Kt/V was 1.1. In Iran had an average value of URR = 53% and Kt/V = 1.17. Similarly, in other developing countries such as Brazil, Nigeria, Nepal, and Pakistan (21), the average value of URR and Kt/V were different from the achievements in developing countries. In America and several countries in Europe, the average value of Kt/V was higher, which was between 1.20 -1.59 (22). Based on the 11th Report of the Indonesian Renal Registry data in 2018, the achievement of HD adequacy in Indonesia was still quite low. Among the total HD procedures in 2018, only 12% achieved the target of URR >80%, and 19% achieved the Kt/V target >1.8. The highest achievement of adequacy in Indonesia was in the value of Kt/V between 1.2-<1.8 and a proportion of 64%. It could be concluded that some patients in Indonesia had not received sufficient HD doses. Pernefri said that the possible cause was because of the time for an HD procedure could not be fulfilled as the large number of patients who had to be served (1).

Another factor that could affect the achievement of HD adequacy in this study was using a dialyzer with an inappropriate size. The dialyzer that used in this study was a Jiangxi Sanxin brand dialyzer, type SM160 L and type SM180 L, with a PES membrane type. The size of the dialyzer is adjusted to the patient's body surface area (BSA), where patients with a larger BSA should get a larger dialyzer size. The following is the formula for calculating BSA:

$$\text{BSA (m}^2\text{)} = \sqrt{\frac{height\ x\ weight}{3600}}$$

In this study, 95% of research subjects used dialyzer type SM160 L with BSA effectiveness up to 1.6 m2, and the rest used dialyzer type SM180 L with BSA effectiveness up to 1.8 m2. Additionally, it was assumed that the average height of Indonesians was 164.5 cm (23). Then, for a dialyzer with type SM160 L, the maximum weight of the patients was 56 kg. Also, a dialyzer with type SM180 L was intended for patients with a maximum weight of ± 70, 9 kg. In selecting the type of dialyzer in the field was not based on BSA calculations in patients but only based on estimation from health workers. In addition, the use of a dialyzer with a larger size in some patients can affect intradialytic complications. According to BSA calculations, if the patients use a larger dialyzer as dialyzers with the wrong size type, it could affect the failure to achieve HD adequacy.

B. The Bivariate Analysis of URR and Kt/V. Values

The relationship between the type of dialyzer with URR and Kt/V values obtained p = 0.90 for URR and p = 0.91 for Kt/V (table 3). It showed that the use of dialyzers among four groups of dialyzer types did not affect HD adequacy achievement in URR and Kt/V values. There was no difference in adequacy achievement between the new dialyzer and the reuse dialyzers. In other words, reuse of dialyzer up to seven times did not affect HD adequacy parameters.

The results of this study are in line with previous studies that assessed the effect of using reuse dialyzer on HD adequacy parameters in the form of URR and Kt/V. However, there were differences in the limits of using reuse dialyzer which was considered safe from various studies. Kashem et al. concluded that the use of reuse dialyzers up to 6 times did not affect the effectiveness when it viewed from the blood urea cleanliness (24). In a cohort study, Aggarwal said that reuse dialyzer did not affect the adequacy value until the 3rd use (14). Furthermore, Armelia stated that reuse dialyzer did not affect adequacy until the average usage was 6.06±2.01 times (25). Also, Purnama found that using reuse dialyzer up to 7 times did not affect the URR and Kt/V values in chronic HD patients (5) and Hamid in his research mentioned that the effectiveness and adequacy of dialysis that achieved from the use of single-use dialyzers could also be achieved by using reuse dialyzers (17). Besides, Dewi concluded that reuse dialyzer is still considered safe when it used the 5th and 6th dialyzers (26). In the four HD units as the setting of this research, the maximum limit of using reuse dialyzer is 7 times as recommended by the researcher.

Table 3. The Bivariate Analysis of URR and Kt/V. Values

			URR			Kt/V		
		N	**Mean (s.b) %**	**Value F/r**	**Value p**	**Value (s.b)**	**Value F/r**	**Value p**
Type of Dialyzer	New	22	70.99 (12.46)	0.19	0.90	1.29 (0.41)	0.16	0.91
	R1-R2	32	70.23 (10.08)			1.26 (0.33)		
	R3-R4	27	69.12 (10.39)			1.23 (0.34)		
	R5-R7	31	71.17(11.78)			1.29 (0.38)		
Gender	Men	67	68.21 (10.38)		0.01	1.20 (0.34)		0.01
	Women	45	7359 (11.24)			1.37 (0.37)		
Age		112	54.49(1.00)	0.00	0.92		0.01	0.85
Comorbidity of DM	With DM	27	69.18 (12.90)		0.52	1.23 (0.42)	0.54	0.54
	Without DM	85	70.75 (10.39)			1.28 (0.34)		
Comorbidity of HT	With HT	79	70.08 (11.54)		0.66	1.26 (0.38)		0.59
	Without HT	33	71.08 (9.75)			1.30 (0.32)		
Length of history of undergoing HD		112		-0.05	0.56		-0.07	0.43
Treated blood time		112		-0.17	0.07		-0.16	0.07
Achieved UF		112		-0.29	0.00		-0.32	0.00
QB		112		-0.11	0.23		-0.12	0.18
TD pre-HD	<140/90	42	71.20 (11.37)		0.53	1.30 (0.37)		0.49
	≥ 140/90	70	69.87(10.83)			1.25 (0.35)		

Moreover, the use of reuse dialyzer has advantages, one of the advantages is to increase the biocompatibility of the dialyzer membrane. In the initial use of a new dialyzer, the dialyzer membrane absorbs plasma proteins on its surface. In using the second dialyzer and so on, the plasma proteins maintain direct contact between the blood and the membrane then it reduces complement activation in blood and blood cells (27). Activation of complement in the blood can make several intradialytic complaints, including hypotension, cramps, sleep disturbances, lethargy, and fever (28). Reducing the activation of complement in the blood is expected to reduce the possibility of intradialytic complaints in patients.

The use of reuse dialyzer is also associated with reducing the possibility of the first use syndrome occurring due to a new dialyzer. First use syndrome is a collection of symptoms that caused by an allergic reaction due to blood in contact with ethyl oxide. A sterilant is found in new dialyzers (27). The reuse dialyzer reprocessing process causes the amount of residual ethylene oxide to decrease. It explains that reuse dialyzer can reduce the possibility of the occurrence of the first use syndrome in patients.

Regarding the adequacy of HD patients, the main concern was the amount of TCV dialyzer in the reuse dialyzer reprocessing process. There was a possibility of TCV reduction at the end of each dialyzer reprocessing. In his report, Hou stated that as long as the TCV is not less than 80%, there is no difference in the adequacy value achieved. A decrease in TCV > 20% is associated with a 10% reduction in blood urea clearance in an HD process (27). The HEMO Study Group reported a 1-2% reduction in blood urea hygiene for every 10-reuse dialyzer (5.8). Thus, Kashem suggested that reuse dialyzer is completed if the TCV reduction is not more than 25% (24).

The reference standard that used in Indonesia in terms of reuse dialyzer by Pernefri. Pernefri stated that reuse dialyzer might encounter AAMI requirements, with the final TCV of tube reprocessing >80%. It was recommended 7 reuses (29). The implementation of reuse dialyzer in four HD units where the research setting had followed the recommendations that was published by Pernefri.

From the bivariate analysis of all research variables, the p-value was less than 0.05 of gender and UF achievement variables. The analysis of the relationship between sex with URR and Kt/V values obtained p = 0.01 (table 3). It intended that statistically, there was a significant difference in the mean of URR and Kt/V between men and women. Gender had a significant effect on the achievement of HD adequacy parameters, where the mean of URR and Kt/V in women were higher than in men. It means that women CKD sufferers had better HD adequacy than males. In addition, the results of the analysis in this study were similar to the previous studies. A study at four HD service centers in Tanzania found that inappropriate HD procedures were more expected to be achieved in men than women, which was 65.6% (21). Besides, in a systematic review by Barzegar, Key found that women is tended to achieve better HD adequacy than men (30) but it was possible due to the use of the same dialyzer, although the volume of men is generally larger than women. Also, the volume of body was influenced by height and it is greater in men. Men who tend to have a larger body size is considered to affect the achievement of Kt/V values. The other factors are lack of muscle mass, less body activity, and better dietary compliance in women (31).

According to the p-value, it was concluded that there was a significant correlation between the value of UF and URR and Kt/V achievements. The value of r was -0.29, and r -0.32 had a weak correlation strength with a negative value that described the opposite direction of the correlation. The higher the achievement of UF value, the lower the URR Kt/V values obtained.

Moreover, fluid withdrawal in the ultrafiltration process was adjusted to the weight gain of the patients due to fluid accumulation. The target amount of fluid to be excreted from the body was calculated based on the estimation excess fluid in the patient, which was objectively proven by measuring body weight before and after the HD procedure as the more excess weight, the more fluid targets that must be removed. Furthermore, the amount of fluid could be removed in the HD procedure in units of time by adjusting the speed of fluid withdrawal or the ultrafiltration rate (UFR). Also, The greater the achieved UF, the greater the UFR value during the HD procedure. The increased UFR was associated with poor outcomes, not only in HD adequacy attainment but also on increasing mortality rates and worsening clinical conditions of patients (32). As yet, It had not been determined how much fluid was considered safe to be removed in one HD procedure. However, the withdrawal of the amount of fluid was determined by the UFR on the HD dose prescription that was associated with patient mortality. According to Saran et al., the UFR > 10 ml/hour/kg BW was associated with a high-risk factor for all mortality, except that it caused by cardiovascular disease (33). In another study, it stated that an increasing of UFR > 13 ml/hour/kg BW was associated with an increasing of all risk factors for death, including risk of death due to cardiovascular disease (34). According to his research, the setting UFR is not more than 10 ml/hour/kg body weight (35)

The Increasing of UFR can make vascular thinning and hypotension, leading to decreased coronary blood flow. It continuously caused ischemia in the heart (36,37). In addition to the heart, ischemia could also occur in the brain (38), digestive tract (39,40), and kidneys. Renal ischemia causes a further decline in residual kidney function and also it can impact the CKD progression (41).

C. The Application of Reuse Dialyzer Related to Cost Efficiency in Type D Hospitals

a. The Calculation of Financing Factors

In the analysis of cost efficiency, the financing factors that were considered to affect the HD procedure using reuse dialyzer and it was compared with the financing factors of single-use dialyzers. The projected financing of single-use dialyzers was essential because there were no HD services at the RSCC that used single-use dialyzers.

The grouping of the reuse group and the single-use group were carried out based on the guidelines in Cost Analysis in Primary Health Care by Creese and Parker (10). Financing is generally divided based on the capital cost and recurrent cost. In some financing items, it was assured that they had the same amount in the two groups because they were not related to changing the use of dialyzers (table 4).

Table 4. The Financing of Reuse Dialyzers and *Single-use Dialyzers*

Financing	*Reuse* Dialyzers Group	*Single-use Dialyzers Group*	Comparison of costs
Capital Cost	Building, room	Building, room	Same in 2 groups
	HD engine Medical equipment Furniture	HD engine Medical equipment Furniture	Same in 2 groups
	Health worker training	Health worker training	Same in 2 groups
Recurrent Cost	Staff salary Reprocessing Dialyzer fee	Staff salary	Addition of financing to the reuse group
	Dialyzer (1:8) Consumables for drugs and non-drugs	Dialyzer (1:8) Consumables for drugs and non-drugs	1. The additional cost of the dialyzer for a single-use group 2. Addition of dialyzer storage capacity in a single-use group
	Outpatient medicine	Outpatient medicine	Same in 2 groups
	Laboratory examination and transfusion program	Laboratory examination and transfusion program	Same in 2 groups
	Overhead Cost: Cost of electricity, water, and consumables for HD procedures and reprocessing dialyzer Medical waste treatment costs	Overhead Cost: Cost of electricity, water, and consumables for HD procedures and reprocessing dialyzer Medical waste treatment costs	1. The addition of overhead costs in the reuse group due to the addition of reprocessing dialyzer procedures 2. Additional funding for handling solid medical waste in the single-use group

The HD procedure movement is one of the aspects that affect the financing factors. The HD procedure is limited to HD services to patients and the reprocessing, and the handling of medical waste. The differences in service movement and financing factors that affect the two groups can be seen in table 5.

Table 5. The Differences of Movement and Financing Factors between Reuse and Single-use Dialyzers Groups

HD Procedure with Reuse Dialyzer	HD Procedure with Single-use Dialyzer	Different Financing Factors
HD Initiation	HD Initiation	-
Preparation for HD	Preparation for HD	Dialyzer Cost
Implementation	Implementation	-
HD implementation	HD implementation	-
Post HD Evaluation	Post HD Evaluation	Electricity cost
Reprocessing Dialyzer	-	Water Treatment Cost Disinfectant Liquid Cost Officer's Wages
Waste Management	Waste Management	Medical waste management costs

The Dialyzer Cost

The dialyzer cost is one of the main factors in the difference in financing in the two groups. The cost of dialyzers in the single-use group was the price for one dialyzer, which was Rp. 192.500. The dialyzer cost in the reuse group was the cost of the total dialyzer usage in March 2021. It divided by the number of HD procedures in that month. In March 2021, 60 dialyzer tubes were used with a total of 421 HD procedures. Thus, the reuse dialyzer cost was Rp. 27.435 /HD procedure (table 6).

The Electricity cost

The electricity costs that calculated in the financing factor are the electricity costs that used during the dialyzer reprocessing. There was no difference in using electricity from the beginning of the procedure to the post-HD evaluation between the two groups. Also, there was no additional electricity cost in the single-use group because there was no reprocessing dialyzer procedure. The calculation of electricity costs in the dialyzer reprocessing is determined by the amount of water that used in one reprocessing procedure. The RO water production capacity, the power of the pump that used in the water treatment system, and the electricity costs is charged to the hospital. The existing data that obtained the cost of electricity financing for one time reprocessing procedure for dialyzer tubes was Rp. 386 (table 6).

The Water Treatment Cost

The cost of water treatment in an HD unit is determined by replacing the filter, membrane, laboratory testing for RO water, and cleaning the tank. The Laboratory checks and tank cleaning process are carried out based on a certain time frame then, it is not related to the capacity of the water produced. Even though, the maximum limit time of the replacement of filters and membranes is determined, the condition of filters and membranes is closely related to the amount of water produced as the greater the amount of water produced, the more frequent the replacement of filters and membranes, and other factors also affect the Quality of raw water. The increasing of the water production is related to the additional cost of water treatment due to the higher frequency of filter and membrane replacement. This additional cost becomes one of the different financing factors between the two groups.

As a unit that implemented reuse dialyzer, filter replacement in the water treatment system in the HD RSCC unit was once in a week, and membrane replacement was once in four months. Hence, it could be determined by calculating the water requirement to calculate each HD procedure's filter and membrane costs. By using a capacity of eight machines and two service shifts every day, it could be calculated the need of the water for HD services and their financing. The water requirement is calculated based on water usage within a week, including the water needed for HD procedures and processing procedures. The cost of financing for one liter of water could be calculated against the cost of the filter and membrane used. Thus, the final cost is the result of multiplying the amount of water needed with the cost per unit liter of the price of the filter and membrane. The final financing charged for a one-time dialyzer reprocessing was Rp. 201 (table 6).

The Liquid Disinfectant Cost

The liquid disinfectant that used in the dialyzer reprocessing is one of the financing burdens for the reuse dialyzer group. The disinfectant that used at the RSCC was a special disinfectant for dialyzer reprocessing with the Farmed MFL 1100 P brand at Rp. 1.512.000/gallon. On February 15, 2021 – March 26, 2021, RSCC was used four gallons of dialyzer liquid disinfectant. In that time, there were 477 dialyzer reprocessing procedures. The result of calculating the cost of the liquid disinfectant based on the data above in the reuse group was Rp. 12.680/reprocessing procedures (table 6).

The Reuse Officer Wage

The nurses was carried out the dialyzer reprocessing procedure at RSCC. In its implementation, there was a payment of wages to the nurse as the officers by the number of dialyzer reprocessing that was carried out. The calculation of the number of wages was a fixed cost of Rp. 5000/dialyzer. During March 2021, there were 365 dialyzer reprocessing procedures with a total of 421 HD procedures in March 2021, the dialyzer reprocessing payment could be calculated as Rp. 4.335 for 1 HD procedure (table 6).

The Medical Waste Management Cost

In March 2021, the solid medical waste was separated specifically for dialyzers. The dialyzer waste is weighed to calculate the load of a used dialyzer in kilograms. The average weight of the dialyzer after used was 0.44 kg. The cost of handling solid medical waste at the RSCC was Rp.11.000/kg. Thus, the charge for 1 tube of medical waste dialyzer was Rp. 4.840.

In the group using reuse dialyzer, the cost of solid medical waste in the form of a dialyzer was Rp. 690 (table 6). In the group using a single-use dialyzer, the projected financing for medical waste costs was Rp. 4.840, equal to the cost of solid medical waste for a dialyzer.

b. The Cost Efficiency in Reuse Dialyzer Application

The analysis of the relationship between reuse dialyzer and the cost efficiency in the HD unit type D hospital can be seen in table 6. From, the six financing factors, there was a difference in the final financing of Rp. 151.613, which was greater in the single-use group. When it related to the amount of payment received by JKN system; Rp. 737.700, then the cost efficiency was 20.55% for each HD procedure.

Table 6. The Calculation of Cost Efficiency in Reuse and Single-use Groups

Different Financing Factors	***Reuse***	***Single-use* (cost projection)**
Dialyzer	27.435	192.500
Electricity	386	0
Water Treatment	201	0
Liquid Disinfectant of Dialyzer Reprocessing	12.680	0
Officer's Wages	4.335	0
Medical Waste	690	4840
Total	**45.727**	**197.340**
Cost Difference	**151.613**	

By the initial analysis regarding the effectiveness of using reuse dialyzer based on HD adequacy achievement, it was found that HD adequacy achievement did not differ between the group using reuse dialyzers and the group using single-use dialyzers. It showed the same outcome on the value of service effectiveness between the groups. The comparison of two procedures/interventions in the cost analysis or economic evaluation that produced the same outcome placed the financing factor as the only factor in the policy determination.

The results of the cost-efficiency analysis in this study are similar to several previous studies as Qureshi conducted a study in Pakistan. He compared the total direct financing between reuse dialyzer and single-use dialyzer. He also concluded that there was a cost efficiency of 14.97% in reuse dialyzer (9). In Bangladesh, the reuse of dialyzers up to 6 times did not change the blood cleansing capacity and saved up to 32% of costs (24). Chuang reported that by using reuse dialyzers, there was a reduction in costs of up to 34.6% (42). Moreover, Aggarwal calculated the savings in using reuse dialyzers of Rs.285 for each HD procedure (14). In using reuse dialyzer five times in China, he will saved 7.280 RMB in cost per patient in every year (27).

The economic reason remains the main reason for applying reuse dialyzer. Although, there are medical advantages to reuse dialyzers such as increasing membrane biocompatibility and reducing the risk of the first-use syndrome. The development of technology and medical equipment can overcome the medical issues. The dialyzer that widely used is already a dialyzer with good membrane biocompatibility even at the first use. It is regarding the possibility of the occurrence of the first-use syndrome in the use of new dialyzers. It is not an important issue because there are many dialyzer products that used safer sterilization methods such as steam, gamma radiation, and e-beam sterilization (43).

The limited amount that provided by JKN makes not all HD services in Indonesia being accommodated for the use of single-use dialyzers (1). In HD units in hospitals with larger types, it is still possible to carry out HD procedures using single-use dialyzers or reuse dialyzers less than seven times and it is not possible in type D hospitals with the smallest number of claims. In a study that calculated HD financing in Malaysia, it was found that the cost charged to each patient for 1 year undergoing the HD procedure was RM 39.790 (44). If these costs were divided into the estimated number of HD procedures in 1 year, then the cost per HD procedure for patients with HD frequency 2 times and 3 times a week was RM 375.3 (Rp. 1.297.001) and RM 250.25 (Rp. 867.667). It was higher than the number of claims that received by type D hospitals in Indonesia, Rp. 737.700.

The application of reuse dialyzer has an impact on waste management in hospitals. By reducing the use of the number of dialyzers, less medical waste is generated. The waste costs were much cheaper in the reuse group (table 7) with a cost difference of Rp.4.150. In March 2021, with a total of 421 HD procedures, the hospital had saved waste costs of Rp. 1.747.150 and an estimated savings was Rp. 20.965.800 within one year. A study in America found that a reduction of solid medical waste to 1000 tons using dialyzer reuse compared to 11.000 tons of medical waste when all HD used single-use dialyzers (43). The reduction of medical waste in the application of reuse dialyzer is also related to social aspects to the environment. It was known that the greater the efforts of the hospital to reduce the volume of medical waste produced then, the greater the contribution of the hospital to prevent damage caused by waste treatment. However, it should also be noted that reuse dialyzer with a dialyzer reprocessing procedure increases hospital liquid medical waste. Further research is needed on using reuse dialyzers when it analyzes the produced medical waste, which was solid medical waste and liquid medical waste.

In Indonesia, the classification of hospital classes is divided into four classess, namely A, B, C, and D classes. The hospital class division is based on the availability of patiens' beds in which type A hospitals meet the standards for the largest number of patients' beds and it followed by types B, C, and D. Furthermore, in different types of hospitals with the same disease diagnosis, the HD service guarantee by the JKN system will be paid with different nominal amounts, where type A hospitals get the largest and type A hospitals get the smallest payments.

The HD unit in type D hospital had implemented a policy of applying the reuse dialyzers to achieve cost efficiency considering the limited funding sources for this procedure. Despite of limited funding sources, the hospitals need to improve cost efficiency due to the high incidence of CKD requiring HD. Chronic Kidney Disease in Indonesia continues to increase (1). Chronic Kidney Disease, commonly referred to as kidney failure as in the four most catastrophic diseases that cost 11.75% of JKN financing by the Health Social Security Administration (BPJS) (45). In India, the financing of HD procedures even contributes for up to 38.1% of the total national financing of catastrophic diseases (46). It is the reason that using reuse of dialyzer is still allowed. Moreover, its application is covered by existing regulations, then it is not considered illegal.

Pernefri is a professional organization that regulates the application of reuse dialyzer in Indonesia. For detailed regulations are needed as symbols considering that the application of reuse dialyzer has the potential for uninvited risks. Some of the risks that arise due to inappropriate use and handling of reuse dialyzer including pyrogen reactions, the incidence of infection, toxic effects of using disinfectants, and decreased cleaning capacity due to decreased TCV in the reprocessing process (27). The valuation of patient outcomes on the use of reuse dialyzer is an important aspect. Hence, it is basically not limited to the application of cost-efficiency. In this study, the application of reuse dialyzer was proven to save cost and did not affect patient outcomes in HD adequacy.

4. Conclusions and Suggestions

There is no difference in HD adequacy between the new and reuse dialyzer. The dialyzers up to seven times were proven not to decrease the achievement of HD adequacy values and saved up to 20.55% of financing sources in type D hospitals. The use of reuse dialyzers could still be done by recommendations set of Penefri.

A dialyzer with a size that matches the BSA of patient was recommended to achieve a better adequacy value. The monitoring and education on controlling fluid intake in patients must continue to be carried out by health workers considering the weight gain, which is directly related to UF achieved, that is one of the determinants of HD adequacy achievement.

Limitation

The effect of reuse dialyzer with increased membrane biocompatibility and decreased incidence of the first-use syndrome could not be proven in this study. It is due to limited data regarding intradialytic complaints. In addition, there are limitations in the financing analysis for handling medical waste because it is only limited to solid waste. Also, the financial data that used only the data on the cost factor in which it distinguishes the reuse group and the projected costs when it carried out in single-use, not based on the actual unit cost. In the setting of this study, there is no group that used a single-use dialyzer.

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