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Original Article

Observational Study on How the Frequency of Dialyzer Reuse Impacts Hemodialysis Effectiveness

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ABSTRACT

Background: The increasing practice of dialyzer reuse in hemodialysis raises critical concerns regarding its impact on efficacy, infection risks, and essential metrics such as Urea Reduction Ratio (URR) and Kt/V values. Addressing these concerns is paramount to establishing safe and optimal reuse limits through comprehensive performance assessments.

Objective: To evaluate the feasibility of dialyzer reuse by assessing Kt/V and URR measurements.

Methods: A prospective cohort study was conducted at RSUD Dr. Saiful Anwar's Hemodialysis Unit from November 2021 to January 2022. Data collection employed a standardized pilot form designed to collate Kt/V and URR data from all participants. Statistical analyses included repeated measures ANOVA to detect temporal changes in average Kt/V and URR, alongside Spearman correlation analysis to explore variable relationships.

Results: The study encompassed 15 participants, revealing a statistically significant decline in both Kt/V and URR values across each reuse group ($p < 0.05$). Specifically, each subsequent reuse of the dialyzer corresponded to a decrement of 0.0469 units in Kt/V and 1.003 units in URR. Notably, by the 7th reuse, hemodialysis adequacy remained satisfactory, achieving an average Kt/V of 1.61. Furthermore, the study indicated that even up to 11 reuses could achieve a Kt/V > 1.4. Similarly, the average URR value for the 7th reuse was 70.207%, with the potential to maintain URR > 65% even after up to 13 reuses.

Conclusion: This study unequivocally affirms that hemodialysis adequacy remains satisfactory up to the 7th reuse of dialyzers, despite observed declines in Kt/V and URR values over successive reuses.

Keywords: Hemodialysis; Kt/V; Urea Reduction Ratio; Reuse Dialyzer; Adequacy.

Introduction

Chronic kidney disease (CKD) represents a substantial global health challenge, affecting a significant portion of the population across various stages.[1] Globally, 13.4% of individuals experience CKD stages 1–5, with 10.6% progressing to stages 3–5. In 2017 alone, CKD accounted for 1.2 million deaths, highlighting its severe impact on mortality rates.[2] Over the period from 1990 to 2017, there was a concerning 41.5% increase in the global all-age mortality rate attributed to CKD.[3] Patients with CKD stages 4 and 5 face particularly high mortality risks, comparable to those undergoing

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dialysis. Specifically, individuals in these advanced stages experience mortality rates three-fold and sixfold higher, respectively, compared to those with an estimated glomerular filtration rate (eGFR) of 60 or higher.[4] Hemodialysis has been a cornerstone therapy for end-stage CKD patients since its inception in the 1960s, effectively managing the condition.[5] However, its implementation comes with significant challenges, notably the substantial financial burden.[6]

The dialyzer device, a critical and expensive component of the treatment process, is a pivotal contributor to the high costs associated with hemodialysis. This expense poses a significant challenge for patients reliant on hemodialysis for kidney function support. Consequently, the reuse of dialyzers has emerged as a promising strategy to mitigate costs.[6] Originating in 1964, the practice of dialyzer reuse has gained widespread adoption,[7] particularly in Indonesia where 92% of dialysis centers engage in reuse practices, averaging between 2 and 10 reuses per dialyzer. This approach has been shown to yield cost savings ranging from 11% to 42%.[8] Despite its cost-effectiveness, dialyzer reuse is not without concerns. Issues such as diminished membrane surface area, which can lead to inadequate dialysis, and infection risks associated with sterilization procedures have been documented.[9] Moreover, prolonged exposure to sterilizing agents poses long-term risks to both patients and equipment. Additionally, repeated use of dialyzers can impact essential metrics of hemodialysis effectiveness, notably reducing Urea Reduction Ratio (URR) and Kt/V values, thereby potentially compromising treatment efficacy.[10] As is well known, both URR and Kt/V are essential for evaluating the outcomes of dialysis. URR provides an assessment of urea removal efficiency, while Kt/V evaluates urea clearance over a specific period and body fluid volume. The implications of not maintaining adequate URR and Kt/V values are highly significant. This can affect patient survival, quality of life, and healthcare costs. Regular monitoring and adjust-ments in dialysis treatment are crucial to ensure that these parameters meet the recommended targets. This is aimed at improving patient out-comes and reducing the burden on healthcare systems. To address these challenges, guidelines such as those from PERNEFRI recommend limiting dialyzer reuse to seven times to balance cost-effectiveness with safety and efficacy considerations.[11] Given these complexities, it is crucial to determine the optimal number of re-uses for each dialyzer to ensure adequate and safe hemodialysis. This study aimed to assess the feasibility of safe dialyzer reuse by evaluating Kt/V and URR measurements, providing in-sights into maintaining hemodialysis adequacy amidst cost-saving practices. This study is expected to provide information on the safety and efficacy of dialyzer reuse, including the maximum number of times it can be safely used for patients.

Methods

Design and participants

The study, a single-center study, was designed as a prospective cohort study conducted at the hemodialysis unit of RSUD Dr. Saiful Anwar between November 2021 and January 2022. The primary objective was to evaluate the efficacy of hemodialysis in patients with chronic kidney disease, comparing those who used reused dialyzers with those who did not. Key parameters assessed included Kt/V and URR. Protocols and procedures throughout the study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for prospective cohort studies.[12]

The sample size for this study was determined based on a prevalence rate of 13.4% among hemodialysis patients,[13] with a minimum power of 80%.[14] This calculation required a minimum of 110 patients in our study. The selection sample method employed was conse-cutive sampling. Inclusion criteria encompassed patients diagnosed with chronic kidney disease undergoing routine hemodialysis at our hospital and who provided written informed consent to participate. Exclusion criteria included patients with hepatitis B and HIV, as well as those who had not undergone reuse of the dialyzer more than seven times. Dropout criteria included patients who did not participate in the study during the study period or who passed away before undergoing dialyzer reuse seven times.

Data collection

The study was conducted at the Hemodialysis Unit of RSUD Dr. Saiful Anwar between November 2021 and January 2022. Data collection utilized a standardized pilot form designed to gather Kt/V and URR data from all participants.

Covariates

The predictor covariate in our study was the use of reused dialyzers, while the outcome covariate was the assessment of hemodialysis adequacy, measured by Kt/V and URR. These covariates were used to evaluate the effectiveness of hemodialysis treatment among participants in our study.

Statistical analysis

In our study, data were presented as mean ± standard deviation (SD) for numerical variables and n (%) for categorical variables. The normality of the data was assessed using the Kolmogorov-Smirnov test, with a p-value less than 0.05 indicating non-normal distribution and a p-value greater than or equal to 0.05 indicating normal distribution. To assess the main findings, repeated measures ANOVA was employed to determine differences in average Kt/V and URR. The selection of the ANOVA test in this study was based on the fact that the variables in this study are numerical and consist of more than two variables. Additionally, Spearman correlation analysis was conducted to examine correlations between variables. The Spearman test was conducted to assess the correlation between variables, as the variables in this study are ordinal and numerical. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS; IBM SPSS; Chicago, US).

Results

Baseline characteristics of patients included in our study

The characteristics of the subjects in this study (Table 1) revealed that 54.8% (63 participants) were male and 45.2% (52 participants) were female. The majority of patients, 96.5% (111 participants), underwent hemodialysis twice a week, while a minority, 3.5% (4 participants), received treatment three times a week. Regarding hemodialysis access, 66.1% (76 participants) had AV-shunt access, 14.8% (17 participants) had double-lumen access, and 19.1% (22 participants) had manual vascular access. Additionally, 0.68% (1 participant) did not have any identified risk factors, 25.85% (38 participants) had risk factors for diabetes mellitus, 67.35% (99 participants) had risk factors for hypertension, 4.08% (6 participants) had risk factors for hyperuricemia, and 0.68% (1 participant) had risk factors for prostate cancer.

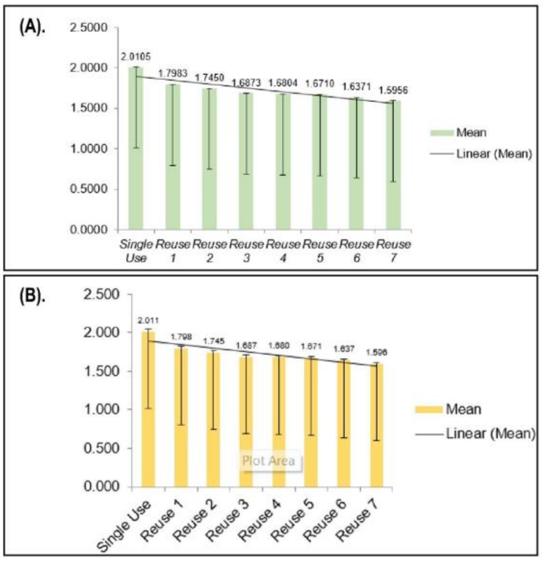
Table 1. Baseline characteristics of patients included in our study

Variables	Percentage
Gender	
Male	63 (54.8%)
Female	52 (45.2%)
Hemodialysis Freq.	
2 times/week	111 (96.5%)
3 times/week	4 (3.5%)
Vascular access	
AV-Shunt	76 (66.1%)
Double lumen	17 (14.8%)
Vein insertion	22 (19.1%)
Risk factor	
Diabetes mellitus	38 (25.85%)
Hypertension	99 (67.35%)
Hyperuricemia	6 (4.08%)
Prostate cancer	1 (0.68%)

Note: data were presented in n (%).

Reuse dialyzer impact on Kt/V

The Kt/V data for single use (new dialyzer) and reuse 1 through reuse 7 exhibited a normal distribution (Figure 1A). This finding allowed for parametric testing. The mean values of Kt/V were 2.011, 1.798, 1.745, 1.687, 1.680, 1.671, 1.637, and 1.596 units, respectively, for each level of dialyzer reuse (Figure 1B). Significant differences ($p < 0.05$) were observed between single-use and each reuse level (reuse 1 through reuse 7), as well as among different reuse levels (e.g., reuse 1 *vs.* single-use and reuse 2 through reuse 7). However, comparisons between specific reuse levels (e.g., reuse 3 *vs.* reuse 4 and reuse 5) did not show significant differences ($p > 0.05$) (Figure 1C). Correlation analysis (Table 2) revealed a negative correlation coefficient of -0.262 with p = 0.000 ($p < 0.05$), indicating a significant relationship between the frequency of dialyzer reuse and Kt/V. This negative correlation suggested that as the frequency of dialyzer reuse increased, Kt/V decreased, while shorter reuse durations were associated with higher Kt/V values. Additionally, a strong correlation coefficient of 0.920 underscored the relationship between dialyzer reuse and Kt/V. Regression analysis yielded the equation: Y = 1.9392 - 0.0469X, where Y represents Kt/V and X represents the frequency of reuse dialyzer. This equation indicated that Kt/V tended to remain high at 1.9392 units but decreased by 0.0469 units with each additional reuse of the dialyzer.



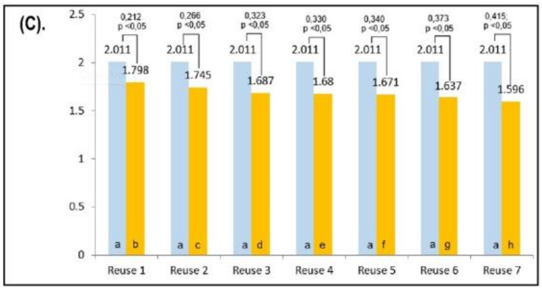


Figure 1. Test outcomes of reuse dialyzer on Kt/V. (A). Normality test outcomes for Kt/V with reused dialyzers. (B). Estimation of the use of dialyzer reuse against Kt/V. (C). Average reduction in Kt/V with reused dialyzers.

Table 2. Correlation test findings for reused dialyzer impact on Kt/V

		Kt/V	Frequency of reuse dialyzer
Pearson correlation	Kt/v	1.000	-.262
	Frequency of reuse dialyzer	-.262	1.000
Sig.(1-tailed)	Kt/v		.000
	Frequency of reuse dialyzer	.000	
N	Kt/v	.920	.920
	Frequency of reuse dialyzer	.920	.920

*Significant if $p<0.05$

The impact of reuse dialyzers on URR

The URR data for single use (new dialyzer) and reuse 1 through reuse 7 exhibited a normal distribution, allowing for parametric testing (Figure 2A). The average URR values were 78.600, 76.218, 75.308, 74.377, 73.435, 73.191, 72.574, and 70.207 units, respectively, for each level of dialyzer reuse (Figure 2B). Significant differences ($p < 0.05$) were found between single-use and each level of reuse (reuse 1 through reuse 7), as well as among different levels of reuse (e.g., reuse 1 *vs.* single-use and reuse 2 through reuse 7). Notably, comparisons between specific reuse levels (e.g., reuse 4 *vs.* reuse 5 and reuse 6) did not show significant differences ($p > 0.05$) (Figure 2C). Correlation analysis (Table 3) revealed a negative correlation coefficient of -0.382 with p = 0.000 (p < 0.05), indicating a significant relationship between the frequency of dialyzer reuse and URR. This negative correlation implied that as the frequency of dialyzer reuse increased, URR decreased, while shorter reuse durations were associated with higher URR values. A strong correlation coefficient of 0.920 further emphasized the relationship between dialyzer re-use and URR. Regression analysis yielded the equation: Y = 78.754 - 1.003X, where Y represented URR and X represented the frequency of dialyzer reuse. This equation suggested that while URR tended to remain high at 78.754 units, each additional use of the reused dialyzer was associated with a decrease of 1.003 units in URR.

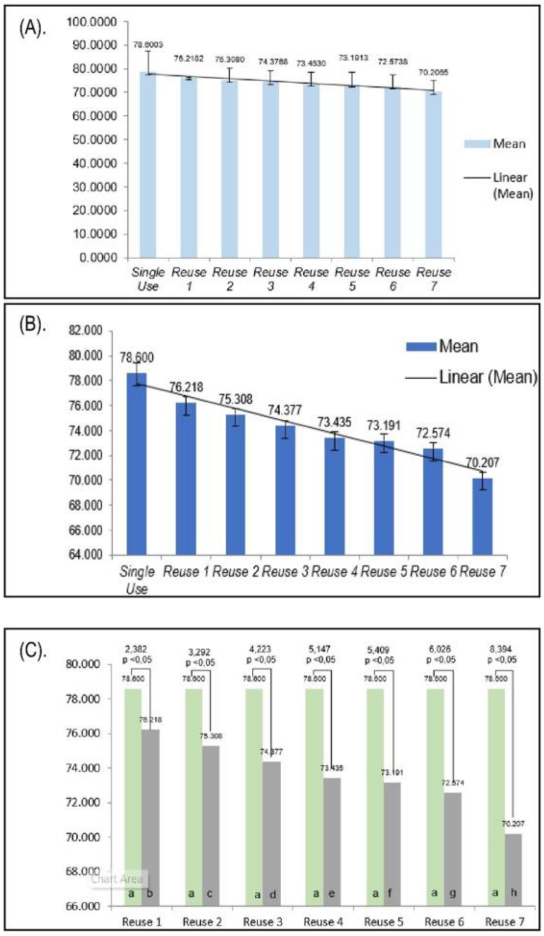


Figure 2. Impact of dialyzer reuse on URR results. (A). Normality test outcomes of dialyzer reuse on URR. (B). Estimate of dialyzer reuse impact on URR. (C). Average decrease in URR with reused dialyzers.

Table 3. Correlation test findings for reused dialyzer impact on URR

		URR	Frequency of reuse dialyzer
Pearson correlation	URR	1.000	-.382
	Frequency of reuse dialyzer	-.382	1.000
Sig.(1-tailed)	URR		.000
	Frequency of reuse dialyzer	.000	
N	URR	.920	.920
	Frequency of reuse dialyzer	.920	.920

*Significant if p<0.05

Discussion

Our study found that the use of a dialyzer up to reuse 7 produced an average Kt/V value of 1.6109 and an average URR value of 71.733. These results are consistent with previous studies that evaluated the impact of dialyzer reuse on Kt/V and URR. Earlier studies reported Kt/V and URR levels of 1.6 ± 0.3 and 74 ± 5, respectively. Furthermore, they indicated that reusing dialyzers up to the 12th reuse was safe from clinical, microbiological, and inflammatory perspectives.[15] Another study demonstrated no significant difference in Kt/V (1.4 ± 0.4) between reused and single-use dialyzers. Additionally, they suggested that reused dialyzers were associated with improved survival rates and lower levels of inflammatory markers, although nutritional markers were not assessed.[16] Moreover, further study revealed no difference in adequacy between single-use and reused dialyzers.[8] These studies supported our findings, indicating that the use of reused dialyzers is safe in terms of hemodialysis adequacy for patients.

In our study, the Kt/V value with reuse of the dialyzer up to the 7th reuse was 1.6109, indicating effective hemodialysis. Previous studies have established safety and adequacy thresholds for Kt/V values. For instance, a study monitoring 80 hemodialysis patients receiving thrice-weekly treatment found that Kt/V values below 1.3 were significantly associated with higher one-year mortality (25%) and shorter survival times (3.3%). Conversely, Kt/V values above 1.4 were linked to lower one-year mortality rates.[17] Another study recommended a Kt/V dose of 1.2 for thrice-weekly hemodialysis,[18] supported by guidelines from the European Renal Best Practice Group (EBPG), which emphasize achieving a Kt/V value ≥1 for optimal treatment outcomes. Values below this threshold are associated with poorer prognoses, whereas a Kt/V above 1.4 is linked with better outcomes compared to values below 1.3.[19] Additionally, further study indicated that a Kt/V above 1.45 is necessary to meet adequate hemodialysis targets. Therefore, our study's finding of a Kt/V of 1.6109 with reused dialyzers underscores their safety and effectiveness in achieving adequacy for hemodialysis patients.[20]

In our study, the URR value with reused dialyzers up to the 7th reuse was 71.733%, indicating effective hemodialysis. Previous studies have assessed the safety and adequacy thresholds of URR values. For example, one study determined that a minimum URR of 65% was necessary for adequate dialysis and found that reused dialyzers could be used up to 13 times while maintaining recommended URR levels.[21] Moreover, a study in India involving 35 patients undergoing long-term hemodialysis showed that an average URR of 66.4% per dialysis was associated with positive outcomes.[22] Similarly, a three-month study in Baghdad on patients with advanced chronic kidney disease identified a minimum URR of 65% as linked to favorable outcomes.[23] Therefore, our study's finding of a URR of 71.733% with reused dialyzers confirms their safety and efficacy in achieving hemodialysis adequacy.

This study has several clinical implications. First, we found that the use of re-used dialyzers was safe, as evaluated based on Kt/V and URR levels. This suggests that reusing dialyzers up to the seventh reuse is highly recommended and safe. Our study confirmed that dialyzer reuse could safely extend to seven cycles without compromising hemodialysis adequacy, highlighting its practical relevance. Given the substantial financial resources required for treatment, this finding is significant for the cost-effectiveness of managing hemodialysis patients.[6] Second, the safety findings regarding reused dialyzers suggest that they do not necessarily need to be new for dialysis patients, as modifications in their reuse can still provide adequate treatment. This could lead to significant cost savings without compromising patient care. Third, however, our study also revealed a decrease in hemodialysis adequacy with reused dialyzers, raising concerns about the safe limit for their reuse. While not substantial in our findings, the decrease indicates the need for ongoing monitoring and assessment to ensure patients receive optimal care. Nonetheless, the complications associated with reused dialyzers, such as infection risk, cardiovascular complications, and impact on patient quality of life, must be carefully considered.[9] While our study supports the safety and efficacy of dialyzer reuse up to seven times, healthcare providers must weigh these benefits against potential risks and ensure that protocols are in place to mitigate any adverse effects.

Conclusion

In conclusion, our study determined that by the 7th reuse of dialyzers, hemodialysis adequacy remained satisfactory with an average Kt/V value of 1.61, above the standard threshold of 1.4, despite a decrease of 0.0469. Similarly, the average URR value on the 7th reuse was 70.207%, exceeding the standard URR of 65%, with a decrease of 1.003. These findings highlight the potential for safe and effective reuse of dialyzers up to the seventh use, which can have significant cost-saving implications for the management of hemodialysis patients. However, future studies should assess factors such as membrane biocompatibility, infection risk, cardiovascular events, quality of life, and cost-effectiveness to better understand the implications of dialyzer reuse. Addressing these aspects and using samples from larger or multi-center studies may help optimize hemodialysis treatment protocols and ensure patient safety and well-being.

Limitations of the Study

This study had several limitations. First, the sample size was small, requiring caution in interpreting the findings. A larger sample size would provide more robust data and allow for more generalized conclusions. Second, potential confounding factors such as underlying diseases, hemodialysis dosage, and comorbidities were not analyzed, necessitating careful consideration when interpreting the results. These factors could influence hemodialysis outcomes and should be included in future studies to provide a more comprehensive understanding. Third, the study did not assess complications associated with reused dialyzers, such as infection risk, cardio-vascular complications, and intradialytic events. These complications are critical to understanding the full impact of dialyzer reuse on patient safety and quality of life.[9] Fourth, membrane bio-compatibility, known to influence hemodialysis adequacy significantly, was not evaluated. Different dialyzer membranes can have varying effects on patient outcomes,[24] and future studies should examine this aspect to determine the best options for dialyzer reuse. Finally, despite the primary objective of cost-effectiveness, the financial aspects of using reused dialyzers were not evaluated. Understanding the economic impact of dialyzer reuse is crucial for healthcare providers and policymakers to make informed decisions about treatment protocols and resource allocation.[6]

Declarations

Ethics approval and consent to participate

The study protocol received approval from the local ethics committee (approval number 070/17231/102.7/2022), adhering to institutional guidelines and the Declaration of Helsinki principles.[25] Participants provided written informed consent after receiving detailed information about the study's aims, potential risks, and benefits. Participants were assured of their voluntary participation and the option to withdraw without consequences.

Competing interests

There are no conflicts of interest in writing this article. This article is written neutrally with actual results.

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Author's Contribution

Idea/concept: RS, AG, NS, AR. Design: RS, AG, NS, AR. Control/supervision: AG, NS, AR. Data collection/processing: RS, AG, NS, AR. Analysis/interpretation: RS, AG, NS, AR. Literature review: RS, AG, NS, AR. Writing the article: RS, AG, NS, AR. Critical review: RS, AG, NS, AR. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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