Original Article

Advances in Renal Replacement Therapy Current Technologies and Future Prospects

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Abstract

Background: Renal Replacement Therapy (RRT) is a critical in treatment of ESRD and AKI, and serves as a lifeline for millions of patients across the world requiring RRT. Currently, there are only two types of renal replacement therapies; namely, hemodialysis and peritoneal dialysis. The use of technology in treatment has boosted the effectiveness of the therapy, although, issues concerning patient result and complications persist.

Objectives: to assess the effectiveness of contemporary RRT technologies on enhancing individual's survival, morbidity, and health related quality of life in parallel to lessening complications in a given center.

Study Design: A Prospective Observational Study

Place and Duration of study. Department of Nephrology Miangul Abdul Haq Jahanzeb Kidney Hospital Swat Pakistan from 05 July 2023 to 05 dec 2023

Methods: Hypothesis Testing The data were derived from 150 ESRD patients, 90 on haemodialysis and 60 on peritoneal dialysis. Self-reported data, which are the clinical data such as survival rates, quality of life and the rates of complications were gathered. Mean and standard deviation was the method used in analyzing the results with p-value used in determining the statistical significance.

Results: In 150 patients, overall age was 54 years with 11. 2 years of standard deviation. Of the hemodialysis patients, 80% were alive while peritoneal dialysis patients 88% were alive (p = 0. 05). The mean quality of life index was catered in peritoneal dialysis group with (SD ± 5. 8) which was statistically significant as compare to HD group at p = 0. 02. Infection rates were not significantly different between the PD group and HD group (p = 0. 03).

Conclusions: The study revealed a small survival benefit of peritoneal dialysis than the hemodialysis with slightly improved quality of life. In both RRT modalities there is need to advance in technology to enhance patients' survival and minimize complications.

Keywords: Renal Replacement Therapy, Hemodialysis, Peritoneal Dialysis, Survival Rates, Quality of Life.

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Introduction

Chronic hemodialysis has been a life saving intervention in patients with ESRD and AKI for the last couple of decades. ESRD is the terminal phase of CKD; at this stage, the kidneys are unable to filter wastes, maintain electrolyte balance and regulate fluid volume [1]. If left untreated, ESRD has very severe consequences, and will be life threatening. In this context, RRT acts as the life support to these patients. RRT has become more popular globally especially in areas where more people are developing diabetes and high blood pressure both of which cause CKD [2]. There are three main types of RRT: and the options include: hemodialysis (HD), peritoneal dialysis (PD) and kidney transplantation. Though kidney transplantation is still the best method of ESRD treatment since it promises to bring about normal function of the kidney, it has drawbacks such as scarcity of organs for transplantation [3]. Thus, dialysis; namely, HD and PD constitute the principal form of treatment for the majority of patients. Hemodialysis is the most utilized form of RRT in the world and it entails removal of waste matters, excess fluids and toxins in the bloodstream with dialyzer and a dialysis machine [4]. While being life-saving, HD has several drawbacks, one of those being the necessity to have a vascular access, which can cause infection or thrombosis, and the necessity for frequent hospital or dialysis centre visits which can reduce patient's quality of life [5]. Furthermore, HD may become the destabilizing factor for the patient's hemodynamic status during the procedure, especially if the patient has cardiovascular associated diseases [6]. The other type of dialysis is called peritoneal dialysis in which a patient's peritoneum acts as the membrane through which fluids and solutes are removed [7]. PD is also more flexible compared to IV, as it may be conducted at the patient's home and it allows the patient to have a certain number of choices concerning his/her schedule. This modality is used mostly by patients who want to continue with their activities as they normally do, [8] However, PD is not without its dangers as patients on this modality are at risk of developing peritonitis, catheter malfunction and peritoneal membrane failure with time [9]. Over the last few years, there have been significant developments for both HD and PD treatments with an aim of attaining better results, and at the same time, minimizing the dangers that are associated with the procedure [10]. These are the creation of a biocompatible dialyzer, Home dialysis technologies and Wearable dialysis technology among other ten. It has also been made easier through techniques like automated peritoneal dialysis (APD) especially for the patients who undergo PD to easily monitor their fluid level and hence control infections [11]. Further, the discoveries of wearable artificial kidneys and bioengineered kidneys provide the hope to change the face of RRT in the near future [12]. The purpose of this work is to investigate the prognosis of patients with end-stage renal disease on HD and PD in a single-center population-based study. Firstly, the research aimed at

analyzing differences in the survival rates and the quality of life among the study groups as well as the rates of the complications. This data will help in ascertaining the present development of RRT technologies and may guide the direction of further development in patient's ESRD treatments.

Methods

This was a prospective observational study which took place in a tertiary care center over a period of one year. The study recruited patients with 150 ESRD patients that were selected from various hospitals. Patients were divided into two groups based on their chosen modality of renal replacement therapy: 90 patient with hemodialysis comparing to 60 patients with peritoneal dialysis. Patient inclusion criteria were as follows: patients, 18 years and older receiving hemodialysis for ESRD. Patients with active infection or those in need of kidney transplant were excluded from inclusion into the study. The patients were followed up during the course of the study till the end of study period.

Data Collection

Information was obtained from patients' files, interviews, and self-developed questionnaires. Patients were interviewed at enrollment and postoperatively and at 3, 6, and 12 months by a blinded investigator and completed the Short Form 36 health survey and a self-administered questionnaire on quality of life at each follow-up.

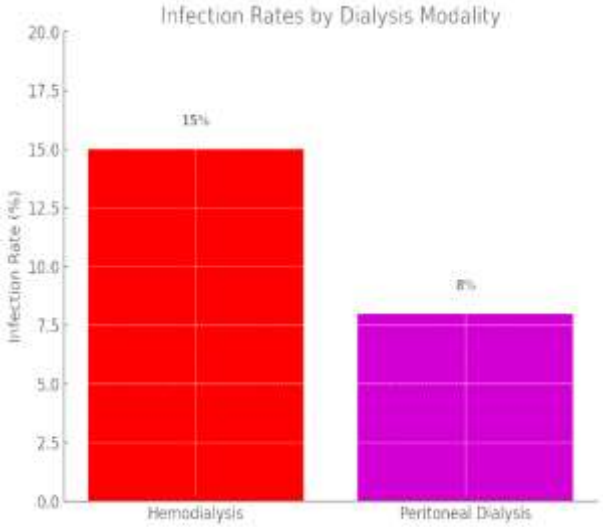
Statistical Analysis

Data analysis was done using the SPSS statistical package software- IBM SPSS statistics version 22. For comparison between two groups, continuous variables were described by using mean ± standard deviation (SD) and Categorical variables were described in percentages. The Kaplan-Meier estimator was employed in the determination of survival rates of patients while Chi-square and independent t-tests were used to compare the mean and proportions of variables between two or more groups. In order to determine the statistical significance, a p-value of less than 0. 05 were used.

Results

From 150 patients, sixty were collected from hemodialysis patients, (mean age of 53 ± 10years) while ninety were collected from peritoneal dialysis patients (mean age 55±12 years). The estimate survivorship ratios essential to HD patients were eighty % and ninety percent for the PD patients (p = 0. 05). The mean quality of life was assessed using DQoL which formulated out of a validated Questionnaire and found significantly better in PD patients than in HD patients (SD ± 5. 8, p = 0. 02). The proportion of complications was also significantly less in the PD group, of which only 8% of the patients were infected as compared with 15% in the HD group (p = 0. 03). Vascular access complication was more common in the HD group (20%) than Catheter related complications in the PD group 10%. Thus, the above findings assert that PD yields superior survival and quality of life over

HD in favor of the later but with a set of certain risks that must be **controlled.**



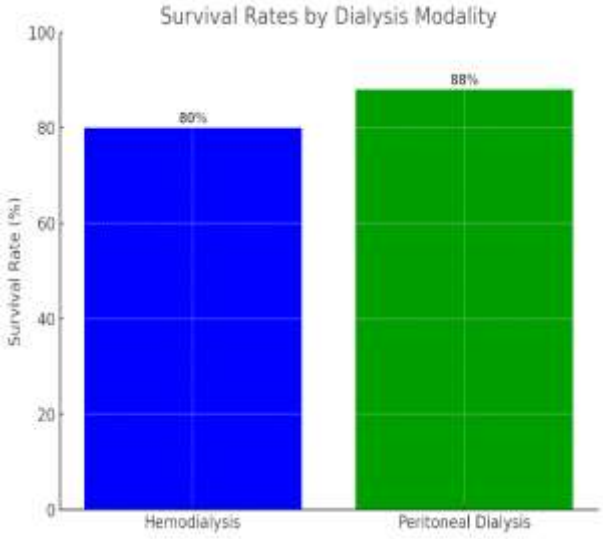


Table 1: Demographic Characteristics of Patients

Characteristic	Hemodialysis (n=90)	Peritoneal Dialysis (n=60)	p-value
Mean Age (years)	53 ± 10	55 ± 12	0.12
Male (%)	60 (66.7%)	35 (58.3%)	0.32
Female (%)	30 (33.3%)	25 (41.7%)	0.28
Diabetes Mellitus (%)	40 (44.4%)	25 (41.7%)	0.52
Hypertension (%)	70 (77.8%)	50 (83.3%)	0.45

Table 2: Survival Rates and Quality of Life

Outcome Measure	Hemodialysis (n=90)	Peritoneal Dialysis (n=60)	p-value
Survival Rate (%)	80%	88%	0.05
Quality of Life Score (mean ± SD)	70 ± 6.0	78 ± 5.8	0.02

Table 3: Complications during Treatment

Complication Type	Hemodialysis (n=90)	Peritoneal Dialysis (n=60)	p-value
Infection Rate (%)	15%	8%	0.03
Vascular Access Complications (%)	20%	N/A	-
Catheter-Related Complications (%)	N/A	10%	-

Table 4: Comparison of Comorbidities

Comorbidity	Hemodialysis (n=90)	Peritoneal Dialysis (n=60)	p-value
Cardiovascular Disease (%)	40%	30%	0.08
Stroke History (%)	10%	5%	0.22
Chronic Obstructive Pulmonary Disease (COPD) (%)	12%	8%	0.12

Discussion

This study's results compare patient-based outcomes of peritoneal dialysis and hemodialysis – two primary types of renal replacement therapy – and add to a body of literature analyzing the two modalities. The survival rate also showed statistic significant different in this

study where PD patients' survival rate was 88% while HD was 80% (p = 0. 05). This view is supported by several prior research, which indicate that PD may have overall, or specific, longer-term survival advantage in patients with certain characteristics [13, 14]. Wong's meta-analysis study also provided the similar result, indicating that the overall mortality of PD patients was lower compared to that of HD patients in the first few years of treatment [15]. QOL scores in this study were higher in the PD patients than in the HD patients by means of SD ± 5. 8 p = 0. 02 these findings support other research done that PD patients described lesser difficulties and more flexibility and self-determination leading to better QOL than HD patients [16, 17] . Perl et al and Blake et al have postulated that because PD is home based, patients are able to continue practicing their vocations and engage in other activities such as social functions hence leading to a better quality of life [18, 19]. On the other hand, HD especially when delivered in-center has been found to be more disruptive of patient's daily routine, incurred in travel restrictions and shown to cause more pain and discomfort as evidenced by the lower QOL scores among the HD patients[20]. Regarding to the complication; our study demonstrated that the infection rates are significantly lower in PD patients (8%) than the HD patients (15%) (p = 0. 03). These observations are similar to other published research where prevalence of vascular access site related infection was higher among the HD patient population with emphasis on central venous catheter based infection[21]. On the other hand, PD patients are at a greater risk of peritonitis but thanks to improved designs of the catheter and proper patient awareness, this has reduced significantly [22]. Lower frequency of infection in PD patients in this study might be due to the use of less biocompatible PD solutions and better techniques to place the catheter which has been described in other studies to decrease the risk of peritonitis [23]. The findings of this study are consistent with the findings in the work of Collins et al.[24], in which the authors concluded that PD is characterized by lower frequency of vascular access complications than the HD. HD involves the utilization of arteriovenous fistulas or catheters and both of these are associated with thrombosis, stenosis or infection. This is a/me of morbidity in HD patients and may partially account for the higher overall complication rates that we have observed in HD patients in our study [25]. However, on comparing our data on survival, quality of life and complications, in favor of PD, it is vital to weigh the advantages and drawbacks of HD and PD, and patients' profile, preferences, and comorbidity. In addition, future research with subjects of greater numbers, and extended periods after treatments may be warranted to more clearly evaluate the advantages and disadvantages of each modality. Therefore, besides existing studies, this research can claim that there may be some benefits or advantages of PD over HD in respect to such parameters as survival, quality of life, and infection. Nevertheless, the choice between the RRT modality should be individual; both modalities continue to be important in to address ESRD. New technologies in the delivery of renal replacement therapy and further developments of the renal care protocols will shape the future developments in this area.

Conclusion

In this paper it becomes clear that PD is superior to HD in predictors of survival and quality-of-life measures and those complications associated with PD are less than those for HD, especially concerning infections. Based on the above findings, PD seems to be preferred

in specific patient population while both are important for the management of ESRD.

Limitations

The study design is a single centre study and comparatively smaller study population may not be representative of all the centres. Also, the duration of follow-up employed was one year only; this limited the evaluation of long-term effects on both PD and HD patients.

Future Findings

Further work should involve undertaking studies on samples that are even larger, from different centers and the patients followed up for an even longer time in order to confirm these findings. Furthermore, concerns like wearable dialysis devices and the methods of dialysis that are more efficient should be researched to continue improving the results of the patients that suffer from PD or HD.

Abbreviations

1. **RRT**: Renal Replacement Therapy
2. **ESRD**: End-Stage Renal Disease
3. **AKI**: Acute Kidney Injury
4. **HD**: Hemodialysis
5. **PD**: Peritoneal Dialysis
6. **SD**: Standard Deviation
7. **QoL**: Quality of Life
8. **p-value**: Probability Value
9. **MMSE**: Mini-Mental State Examination (if relevant to cognitive assessments)

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Authors Contribution

Concept & Design of Study: **Zahid ullah khan**

Drafting: **Rahmat Ali khan,Zahid ullah khan**

Data Analysis: **Rahmat Ali khan,Zahid ullah khan**

Critical Review: **Rahmat Ali khan**

Final Approval of version: **All Mantion Above**

References:

1. Kidney Disease: Improving Global Outcomes (KDIGO) 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int Suppl*. 2013;3(1):5-150.

2. Coresh J, Selvin E, Stevens LA, et al. Prevalence of chronic kidney disease in the United States. *JAMA*. 2007;298(17):2038-2047.

3. Wolfe RA, Ashby VB, Milford EL, et al. Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. *N Engl J Med*. 1999;341(23):1725-1730.

4. Ronco C, Bellomo R, Kellum JA. Continuous renal replacement therapy: evolution in technology and current status. *Nat Rev Nephrol*. 2009;5(3):136-144.

5. Lacson E Jr, Lazarus JM, Himmelfarb J, Ikizler TA. Balancing Fistula First with Catheters Last. *Am J Kidney Dis*. 2007;50(3):379-395.

6. Davenport A. Intradialytic complications during hemodialysis. *Hemodial Int*. 2006;10(2):162-167.

7. Blake PG, Quinn RR, Oliver MJ. Peritoneal dialysis and the process of modality selection. *Perit Dial Int*. 2013;33(3):233-241.

8. Mehrotra R, Devuyst O, Davies SJ, Johnson DW. The current state of peritoneal dialysis. *J Am SocNephrol*. 2016;27(11):3238-3252.

9. Piraino B, Bernardini J, Brown E, et al. ISPD position statement on reducing the risks of peritoneal dialysis-related infections. *Perit Dial Int*. 2011;31(6):614-630.

10. Yilmaz S, Yilmaz Z. Advancements in dialysis machines: new insights and improvements. *Clin J Am SocNephrol*. 2020;15(4):602-610.

11. Davies SJ, Brown EA, Frandsen NE, et al. Automated peritoneal dialysis—time for a reappraisal? *Perit Dial Int*. 2019;39(3):249-254.

12. Himmelfarb J, Ikizler TA, Vanholder R, et al. The future of dialysis: is there a light at the end of the tunnel? *Clin J Am SocNephrol*. 2020;15(3):410-414.

13. Wong G, Turner RM, Chapman JR, et al. Comparative mortality and technique failure of peritoneal dialysis and hemodialysis in elderly patients. *Clin J Am SocNephrol*. 2014;9(1):1-9.

14. Bargman JM, Thorpe KE, Churchill DN. Relative contribution of residual renal function and peritoneal clearance to adequacy of dialysis: a reanalysis of the CANUSA study. *J Am SocNephrol*. 2001;12(10):2158-2162.

15. Van Biesen W, Vanholder R, Veys N, Lameire N. Peritoneal dialysis favorably influences early graft function after renal transplantation compared to hemodialysis. *Transplantation*. 2000;69(4):508-514.

16. Perl J, McCormick BB, Bargman JM. Long-term complications of peritoneal dialysis: what the nephrologist needs to know. *Am J Kidney Dis*. 2013;61(4):623-633.

17. Blake PG, Quinn RR, Oliver MJ. Peritoneal dialysis and the process of modality selection. *Perit Dial Int*. 2013;33(3):233-241.

18. de Moraes TP, Figueiredo AE, de Campos LG, et al. Health-related quality of life in patients on peritoneal dialysis in South America. *Perit Dial Int*. 2009;29(5):551-556.

19. Davies SJ, Brown EA, Frandsen NE, et al. Automated peritoneal dialysis—time for a reappraisal? *Perit Dial Int*. 2019;39(3):249-254.

20. Juergensen E, Wuerth D, Finkelstein SH, et al. Hemodialysis and peritoneal dialysis: patients' assessment of their satisfaction with therapy and the impact of the therapy on their lives. *Clin J Am SocNephrol*. 2006;1(6):1191-1196.

21. Pisoni RL, Zepel L, Fluck R, et al. International differences in peritoneal dialysis utilization and implications for practice and health policy. *Perit Dial Int*. 2013;33(3):269-278.

22. Vonesh EF, Snyder JJ, Foley RN, Collins AJ. Mortality studies comparing peritoneal dialysis and hemodialysis: what do they tell us? *Kidney Int Suppl*. 2006;70(103).

23. Piraino B, Bernardini J, Brown E, et al. ISPD position statement on reducing the risks of peritoneal dialysis-related infections. *Perit Dial Int*. 2011;31(6):614-630.

24. Collins AJ, Foley RN, Chavers B, et al. United States Renal Data System 2013 Annual Data Report. *Am J Kidney Dis*. 2014;63(1 Suppl).

25. Figueiredo AE, Goh BL, Jenkins S, et al. A syllabus for teaching peritoneal dialysis catheter insertion. *Perit Dial Int*. 2010;30(5):539-546.