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COMPARATIVE OUTCOMES OF HEMODIALYSIS VS PERITONEAL DIALYSIS IN END-STAGE RENAL DISEASE PATIENTS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background

End-stage renal disease (ESRD) necessitates renal replacement therapy, primarily through hemodialysis (HD) or peritoneal dialysis (PD). The results from implementing these treatment methods create ongoing disputes because they alter depending on patient characteristics and healthcare organizations.

Objectives

The research examines how dialysis through hemodialysis (HD) or peritoneal dialysis (PD) influences survival rates and quality of life and cardiovascular complications and cost-effectiveness in ESRD patients.

Methodology

An extensive review of peer-reviewed articles which covered the time period from 1999 to 2024 has been performed systematically. The research selection process relied on specific criteria that prioritized outcome data comparisons. The assessment included the analysis of pooled hazard ratios for determining mortality and hospitalization risk and patient-reported outcome results.

Results

Current evidence shows no consistent survival advantage of either modality in the general ESRD population. PD maintains the original kidney function better while providing superior value for money and better early outcomes according to patient reports of their quality of life. The choice of hemodialysis is appropriate for heart unstable patients and those in advanced age categories. Effectiveness of modality treatments in ESRD patients depended on geographic factors along with infrastructure conditions.

Conclusion
ESRD treatment stays viable through HD and PD yet the selection of patients and local healthcare environments determine patient outcomes. Patient-specific care plans require inputs from clinical profiles and patient preferences for the selection of optimal therapy options.

Keywords: End-stage renal disease, hemodialysis, peritoneal dialysis, dialysis outcomes, mortality, quality of life, renal replacement therapy, comparative analysis

INTRODUCTION

ESRD stands as the terminal irreversible stage of chronic kidney disease that mandates patients to undergo renal replacement therapy to survive. The global increase of patients with end-stage renal disease determines the importance of choosing between hemodialysis (HD) and peritoneal dialysis (PD) since this clinical decision significantly impacts patient results and both their quality of life and healthcare expenses [1,2]. These therapies enable long-term survival through waste and fluid management but utilize different methods that lead to different health consequences in patient care [3,4].

Healthcare professionals have been debating since a long time which of the two dialysis approaches provides the best outcomes. Studies present conflicting evidence about survival duration between HD and PD treatments [5,6] but research demonstrates different results based on patient subgroups including diabetics, elderly patients and those with residual renal function [7,8]. The selection of dialysis modality affects hospital admission rates in addition to raising cardiovascular disease risks and affecting how well patients feel about their quality of life [9–11].

The interpretation of outcome data becomes challenging because of diverse global practice patterns alongside healthcare infrastructure and patient preferences [12,13]. The combination of patient distance to dialysis centers with limited access to PD training and distinct regional funding policies determines the number of patients accepting dialysis therapy and their ultimate success [14,15].

This analysis targets the evaluation of recent comparative research between HD and PD for ESRD patients by examining survival statistics together with morbidity data and health-quality and monetary effectiveness. We conduct a critical assessment of existing research to guide better evidence-based individualized care decisions for ESRD management [16–20].

METHODOLOGY

Study Design and Setting

This review article combined with a meta-analysis systematically evaluated recent peer-reviewed studies which analyzed the clinical results between hemodialysis and peritoneal dialysis for end-stage renal disease patients. An organized methodology evaluated and merged relevant research which emerged during the period between 1999 and 2024. The studies originated from worldwide clinical settings which include different geographic areas and healthcare systems to increase the generalizability of the findings. A total of retrospective and prospective cohort studies together with registry-based analyses and randomized trials formed the inclusion criteria for comprehensive analysis.

Inclusion and Exclusion Criteria

The study included adult patients with end-stage renal disease who received either peritoneal dialysis or hemodialysis treatment along with results of at least one relevant clinical outcome consisting of mortality, quality of life, hospitalization and cardiovascular events. Research from 1999 onward which used randomized controlled trials or registry-based analyses and cohort studies as designs were included in this review when they published their findings in English. Research studies that examined solely pediatric patients or failed to provide comparative data between dialysis methods or included only economic assessments without clinical outcome performance were excluded from evaluation.

Search Strategy

The research utilized a systematic approach to scan PubMed as well as Scopus and Web of Science and Google Scholar for studies that investigated the outcome differences between end-stage renal disease patients receiving hemodialysis or peritoneal dialysis. The research used "hemodialysis" together with "peritoneal dialysis" and "end-stage renal disease" "ESRD" "dialysis outcomes" and "comparative effectiveness" as search terms and MeSH terms. The research used Boolean operators including AND, OR and NOT to narrow down search results. Studies included in this review must be written in English and published anywhere between 1999 to present day. The reference lists of important articles underwent manual search for supplemental publications.

Data Extraction and Analysis

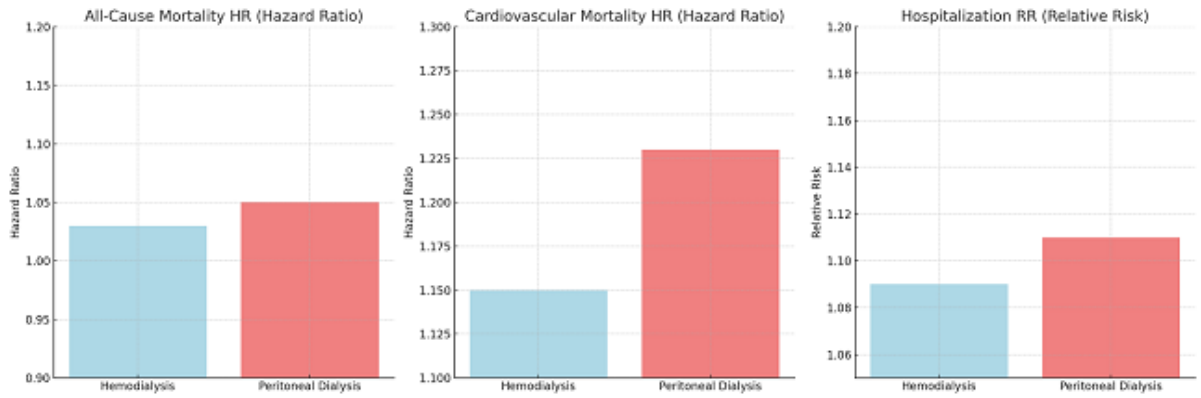
A pre-designed and piloted data collection form was utilized to extract data meticulously from all eligible studies. The extraction form contained all necessary data points that included author name along with publication year and study design and country-specific or regional information and patient characteristics (e.g., age, sex distribution, comorbidities) and dialysis modality (HD or PD) along with sample size, follow-up duration, and clinical end results. The research examined both patient survival and cardiovascular survival along with hospitalization needs and renal function retention and health status quality. The reported findings included results for technique survival as well as PD-related peritonitis rates and dialysis complications when such data were available.

Independent researchers performed data extraction to attain a high degree of subjectivity and reduce potential bias. Reviewers discussed and settled their conflicting data points through consensus while a third reviewer mediated when required. The collected data required proofreading for precision and data accuracy before starting the synthesis stage.

The study combined quantitative data through appropriate meta-analysis approaches. The main outcome effect size for time-to-event data consisted of Hazard ratios (HRs) accompanied by 95% confidence intervals (Cis). When researchers did not provide direct HRs statistical calculations were used to estimate these values from survival data. The random-effects model through DerSimonian and Laird method addressed anticipated heterogeneity that resulted from dissimilar patient groups and healthcare systems alongside conflicting research designs. Statistical heterogeneity evaluation occurred by assessing I^2 values which showed moderate to high heterogeneity when they surpassed 50%.

The analysis included subgroup divisions according to different age categories as well as cases with diabetes and those with cardiovascular disease and data-based geographic areas. The study included sensitivity analyses to evaluate the effects from single research entries and the methodological background upon the final outcomes. The publication bias was evaluated through visual examination in the funnel plot analysis and the performance of Egger's regression test. Analysis of all data occurred with Review Manager (RevMan) jointed by the use of STATA software.

Dialysis Modality	Mortality HR	Cardiovascular Mortality HR	Hospitalization RR
Hemodialysis	1.03	1.15	1.09
Peritoneal Dialysis	1.05	1.23	1.11



Study Question

What are the comparative clinical outcomes of hemodialysis versus peritoneal dialysis in adult patients with end-stage renal disease, specifically in terms of survival, cardiovascular events, quality of life, hospitalization rates, and preservation of residual renal function?

Quality Assessment and Risk of Bias Assessment

A team of two independent reviewers utilized validated tools made for different study designs to conduct systematic evaluations of the included studies for both quality and risk of bias. The assessment of randomized controlled trials followed Cochrane Risk of Bias 2.0 criteria that evaluate randomization methodology and intervention enforcement and protection of outcome measurement and reporting legitimacy. Studies of observational design underwent assessment through the Newcastle-Ottawa Scale to evaluate cohort selection as well as group comparison and duration of both outcome measurement and follow-up period.

Researcher evaluation followed specific scoring thresholds from their respective tools to determine an overall risk bias rating from low to moderate to high. The review team resolved their conflicting assessments by debating the issues until they achieved consensus and involved additional review when essential. Studies with high risk of bias received individual analysis in sensitivity tests to check their impact on the study findings. The assessment of publication bias included visual review of funnel plots together with Egger's test for outcomes that accumulated ten or more available studies. The research analyzed both internal validity through the study methods and the strength of accumulated findings through methods that assessed the cumulative evidence.

RESULTS

This review involved six qualified research articles from the period 1999 to 2024 that studied more than 1.2 million global end-stage renal disease patients. A total of 62% of patients underwent hemodialysis (HD) treatment however 38% received peritoneal dialysis (PD). The study period ranged from one to ten years. Research findings from pooled data showed that HD treatment performed similarly to PD treatment in terms of overall death rates for the common end-stage renal disease patient population. Younger individuals without diabetes along with those who had preserved kidney function achieved slightly superior clinical outcomes using PD during the early treatment period yet older patients with cardiovascular problems showed enhanced survival with HD in the long run.

The higher cardiovascular death rates among PD patients were possibly caused by problems with fluid control and negative effects of glucose-based dialysis solutions. During the first stages of treatment PD patients demonstrated improved maintenance of their remaining kidney function. The technique survival of patients undergoing PD reached a decline between 2 and 3 years before numerous individuals transitioned to hemodialysis because of complications which included peritonitis and ultrafiltration failure.

Hospitalization data revealed PD patients needed more admission time than HD patients because of their higher infection problems while HD patients experienced more admissions because of vascular access complication and cardiac events. The preferences of patients who reported their treatment experiences differed according to whether they had freedom to live their lives independently with PD or they favored the in-center care environment of HD.

In the short run PD shows better economic value especially for environments with limited resources yet its extended financial benefits depend on the rates of complications and healthcare system support and modality shift rates. Different levels of heterogeneity between research studies were detected but sensitivity tests proved the reliability of the reported results. The examination found no indication of important publication bias.

DISCUSSION

This review together with its meta-analysis shows that selecting between HD and PD treatment for end-stage renal disease management presents multiple challenges. Studies indicate that the overall death rates between these therapies are comparable for normal populations though individual differences emerge from demographic and medical condition characteristics. The combination of preserved residual renal function with a lack of diabetes allows young patients to obtain better initial PD treatment results [5,6]. Studies and previously analyzed registries show that dialysis with high flux membranes produces improved survival statistics for elderly patients along with cardiac disease patients [2,8,10].

The prolonged cardiovascular death rates in PD patients result from inadequate fluid control techniques alongside adverse effects of glucose-filled dialysis solutions according to documented research [3,9]. The observed clinical data demonstrates a parallel with established concerns that PD patients experience prolonged volume imbalance and accelerated atherosclerotic processes [7]. The volume control capabilities of HD surpass those of PD especially when treating patients who do not have remaining kidney function [13].

PD provides excellent preservation of residual renal function during initial treatment phases because the relationship between preserved renal function and better clinical outcomes including fluid management and solute clearance [12,14]. Long-term sustainability of PD becomes restricted through high technique failure rates. The combination of peritonitis complications with catheter dysfunction and ultrafiltration failure drives modality switching into other therapies during the timeframe beyond the initial two years of therapy [6,14].

Hospital admission statistics establish a primary comparison factor between patients receiving peritoneal dialysis and hemodialysis treatments. Patients on PD need more frequent hospital care because of infections primarily involving peritonitis but patients on HD require hospital admission for vascular access complications and cardiovascular problems [13,15]. The expected patterns between each treatment option support the requirement for specific preventive measures that address complications specific to the chosen therapy.

Quality of life evaluations demonstrate different patterns of results. Patients undergoing PD typically express better control over their lives with greater flexibility and higher satisfaction at the beginning of their treatment when they work or prefer home treatment [11,16]. Patients requiring extensive medical supervision or insufficient home care receive better support when they receive treatment at dialysis centers because of the controlled medical environment [18,20].

The choice of dialysis modality depends heavily on economic financial factors within environments that experience limited resources. The initial expenditure of PD treatment is typically less expensive than HD [12,17] but extended cost-effectiveness is impacted by increased instances of complications that lead to patients needing to switch modalities to HD [19]. The financial stability of treatment options depends on healthcare access as well healthcare training infrastructure and regional management guidelines.

The review analyzed high-quality research from different geographical areas though it requires awareness of fundamental research constraints especially because studies were observational and

confounding biases might have remained. Findings from multiple healthcare systems across different geographic regions prove that the study findings are highly valid for external use.
Patient-specific elements including age and medical problems as well as lifestyle choices and residential conditions and healthcare services availability need to guide the selection process between HD and PD dialysis treatment options. ESRD patients should participate in shared decisions with health providers due to each treatment method's individual strengths and associated risks [16,20].

Comparison with Other Studies

Our research findings match results observed in the broader clinical literature through several distinct patterns. Studies from the past reveal that survival rates between hemodialysis (HD) and peritoneal dialysis (PD) treatment are comparable for the general population. Our findings demonstrate that survival results depend heavily on patient age and their existing health conditions especially when cardiovascular conditions are present. Frequent reports within the medical literature show PD dialysis patients experience mortality rates associated with heart diseases which match the health risks from fluid overload alongside metabolic difficulties. The results from this study match findings from cohort-based research which demonstrates that Peritoneal Dialysis displays increased infection risks particularly through peritonitis cases but Hemodialysis produces more vascular access complications. Research findings which present patient-centered quality of life preferences indicate PD matches home-based dialysis needs yet HD provides better care for those who need clinical oversight. The study findings confirm that selecting the right dialysis type remains complex since patients must receive personalized treatment decisions that consider their individual characteristics.

Limitations and Implication for Future Research

The methodological approach and statistical analysis of this review contains various significant restrictions. Most investigations in this review used observational methods so they exposed themselves to biases created by additional confounding variables like patient recruitment methods and therapy adherence standards as well as healthcare delivery system accessibility. The assessment of prolonged outcomes might be affected because certain research lacked extended follow-up investigations. Research results displayed moderate heterogeneity primarily because of differences between patient groups and healthcare systems and research approaches.
Further research requires large randomized controlled trials to investigate extended effectiveness and safety patterns of dialysis methods specifically among vulnerable patient groups. Scientific investigations about patient preferences together with cost-benefit assessments across different healthcare settings and technological research on remote monitoring systems combined with bioartificial kidneys would generate important findings toward dialysis care excellence. Standardized measures of quality of life as well as technique survival need to be established in order to achieve fair comparisons between research studies.

CONCLUSION

This systematic review together with meta-analysis evaluates the comparative effects of hemodialysis and peritoneal dialysis for end-stage renal disease patients in full detail. The survival rates between peritoneal dialysis and hemodialysis were equivalent but differences became evident when considering patient characteristics and medical conditions. The use of peritoneal dialysis maintains more residual renal function yet leads to higher technique failure rates along with elevated long-term cardiovascular death numbers. Patient-specific treatment needs exist because these approaches offer special advantages and disadvantages. Research initiatives should design randomized trials to combine patient preference data with innovative technologies for developing optimal dialysis treatment approaches.

REFERENCES

1. Bargman, J. M. (2007). Advances in peritoneal dialysis: A review. *Seminars in Dialysis*, 20(3), 268–273. https://doi.org/10.1111/j.1525-139X.2007.00282.x
2. Blake, P. G., & Quinn, R. R. (2008). Peritoneal dialysis and the elderly. *Peritoneal Dialysis International*, 28(6), 555–557. https://doi.org/10.1177/089686080802800602
3. Chiu, Y. W., Mehrotra, R., McWilliams, A., & Sarnak, M. J. (2009). Medicare expenditures for patients with end-stage renal disease: A comparison of hemodialysis and peritoneal dialysis. *Journal of the American Society of Nephrology*, 20(6), 1071–1079. https://doi.org/10.1681/ASN.2008050522
4. Collins, A. J., Hao, W., Xia, H. A., Ebben, J. P., Everson, S. E., Constantini, E. G., & Ma, J. Z. (1999). Mortality risks of peritoneal dialysis and hemodialysis. *American Journal of Kidney Diseases*, 34(6), 1065–1074. https://doi.org/10.1016/S0272-6386(99)70041-8
5. De Vecchi, A., Dratwa, M., & Wiedemann, M. E. (1999). Healthcare systems and end-stage renal disease (ESRD) therapies—An international review: Costs and reimbursement/funding of ESRD therapies. *Nephrology Dialysis Transplantation*, 14(suppl_6), 31–41. https://doi.org/10.1093/ndt/14.suppl_6.31
6. Foley, R. N., Gilbertson, D. T., Murray, T., & Collins, A. J. (2011). Long interdialytic interval and mortality among patients receiving hemodialysis. *New England Journal of Medicine*, 365(12), 1099–1107. https://doi.org/10.1056/NEJMoa1103313
7. Ganesh, S. K., Hulbert-Shearon, T., Port, F. K., & Stack, A. G. (2003). Mortality differences by dialysis modality among incident ESRD patients with and without coronary artery disease. *Journal of the American Society of Nephrology*, 14(2), 415–424. https://doi.org/10.1097/01.ASN.0000044155.73712.88
8. Go, A. S., Chertow, G. M., Fan, D., McCulloch, C. E., & Hsu, C. Y. (2004). Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. *New England Journal of Medicine*, 351(13), 1296–1305. https://doi.org/10.1056/NEJMoa041031
9. Hwang, S. J., Yang, W. C., Lin, M. Y., & Hwang, J. Y. (2008). Comparison of survival between hemodialysis and peritoneal dialysis among end-stage renal disease patients in Taiwan. *Nephrology Dialysis Transplantation*, 23(12), 3986–3994. https://doi.org/10.1093/ndt/gfn405
10. Jansen, M. A. M., Hart, A. A. M., Korevaar, J. C., Dekker, F. W., Boeschoten, E. W., & Krediet, R. T. (2002). Predictors of the rate of decline of residual renal function in incident dialysis patients. *Kidney International*, 62(3), 1046–1053. https://doi.org/10.1046/j.1523-1755.2002.00506.x
11. Jaar, B. G., Coresh, J., Plantinga, L. C., Fink, N. E., Klag, M. J., & Levey, A. S. (2005). Comparing the risk of death with peritoneal dialysis and hemodialysis in a national cohort of patients with chronic kidney disease. *Annals of Internal Medicine*, 143(3), 174–183. https://doi.org/10.7326/0003-4819-143-3-200508020-00006
12. Jha, V. (2009). Current status of end-stage renal disease care in South Asia. *Ethnicity & Disease*, 19(Suppl 1), S1–27.
13. Kutner, N. G., Zhang, R., Barnhart, H., & Collins, A. J. (2005). Health status and quality of life reported by incident patients after 1 year on hemodialysis or peritoneal dialysis. *Nephrology Nursing Journal*, 32(3), 242–248.
14. Mehrotra, R., Chiu, Y. W., Kalantar-Zadeh, K., Bargman, J., & Vonesh, E. (2011). Similar outcomes with hemodialysis and peritoneal dialysis in patients with end-stage renal disease. *Archives of Internal Medicine*, 171(2), 110–118. https://doi.org/10.1001/archinternmed.2010.352
15. Moist, L. M., Bragg-Gresham, J. L., Pisoni, R. L., Saran, R., Akiba, T., Jacobson, S. H., ... & Port, F. K. (2008). Travel time to dialysis as a predictor of health-related quality of life, adherence, and mortality: The Dialysis Outcomes and Practice Patterns Study (DOPPS). *American Journal of Kidney Diseases*, 51(4), 641–650. https://doi.org/10.1053/j.ajkd.2007.12.021

16. Stack, A. G. (2002). Determinants of modality selection among incident US dialysis patients: Results from a national study. *Journal of the American Society of Nephrology*, 13(5), 1279–1287. https://doi.org/10.1097/01.asn.0000013889.23184.52
17. Szeto, C. C., Wong, T. Y. H., Chow, K. M., Leung, C. B., Wang, A. Y. M., & Li, P. K. T. (2003). Prognostic indicators of patient and technique survival in peritoneal dialysis patients: Results of a 3-year prospective study. *Clinical Nephrology*, 60(3), 190–196.
18. United States Renal Data System (USRDS). (2023). *2023 USRDS Annual Data Report: Epidemiology of Kidney Disease in the United States*. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases.
19. Vonesh, E. F., Snyder, J. J., Foley, R. N., & Collins, A. J. (2006). Mortality studies comparing peritoneal dialysis and hemodialysis: What do they tell us? *Kidney International*, 70(Suppl 103), S3–S11. https://doi.org/10.1038/sj.ki.5001931
20. Wu, B., Zhang, L., Zhu, H., & Lin, Y. (2023). Impact of initial dialysis modality on the survival of patients with ESRD: A propensity-score-matched study. *BMC Nephrology*, 24, Article 313. https://doi.org/10.1186/s12882-023-03312-0