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COMPARATIVE ANALYSIS OF HEMODIALYSIS AND PERITONEAL DIALYSIS IN RENAL FAILURE

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ABSTRACT

End-Stage Renal Disease (ESRD) is characterized by the irreversible loss of kidney function, requiring renal replacement therapies such as Hemodialysis (HD) or Peritoneal Dialysis (PD) to maintain patients' health and quality of life. This systematic review compares HD and PD regarding quality of life, survival outcomes, and cost-effectiveness. A comprehensive search was conducted in PubMed and SciELO databases for studies published between 2014 and 2023, using keywords such as "Peritoneal Dialysis," "Hemodialysis," and "End-Stage Renal Disease." Of the 37 initially identified articles, 15 met the inclusion criteria. Findings indicate that PD improves aspects of quality of life, particularly mental health and the impact of kidney disease, as reported by Zazzeroni et al. (2017). However, HD offers superior control of hemodynamic disturbances, making it preferable for patients with severe comorbidities, such as diabetes and cardiovascular diseases. Regarding survival, studies by Mousavi et al. (2015) and Rigoni et al. (2016) revealed no significant differences in early treatment years, although mortality is higher among diabetic and elderly patients on PD, as highlighted by Yang et al. (2015). Additionally, PD demonstrated greater cost-effectiveness, especially in resource-constrained settings, according to Chang et al. (2016). The review underscores the importance of individualizing treatment decisions based on clinical factors, patient preferences, and available infrastructure. While PD offers advantages in quality of life and cost-effectiveness, HD remains more suitable for patients with severe comorbidities. Further research is needed to refine treatment protocols and improve outcomes for ESRD patients.

Keywords: Peritoneal Dialysis. Hemodialysis. End-Stage Renal Disease. Quality of Life. Survival Outcomes. Cost-Effectiveness.

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INTRODUCTION

End-Stage Renal Disease (ESRD) represents the most severe stage of chronic kidney disease, defined by the progressive and irreversible loss of kidney function. This condition results in the inability to eliminate waste products, regulate fluid balance, and maintain electrolyte homeostasis, leading to life-threatening complications such as severe hypertension, pulmonary edema, and arrhythmias. ESRD frequently stems from common chronic conditions like diabetes mellitus, systemic arterial hypertension, chronic glomerulonephritis, and vascular diseases. For these patients, renal replacement therapies, including Hemodialysis (HD) and Peritoneal Dialysis (PD), are critical for survival and play an integral role in maintaining health and quality of life (Universidade Aberta do SUS, 2024).

Hemodialysis (HD) is a widely used modality that involves the filtration of blood through an artificial membrane outside the body. It effectively removes toxins, corrects electrolyte imbalances, and stabilizes fluid overload. However, the procedure requires vascular access through an arteriovenous fistula or a central venous catheter, which introduces risks such as infections, clot formation, and vascular damage. Additionally, HD sessions are conducted in clinical settings on a fixed schedule, often causing disruptions to patients' daily lives. Its intermittent nature also contributes to hemodynamic instability, characterized by fluctuations in blood pressure and weight, and accelerates the decline of residual kidney function. Despite these challenges, HD is particularly advantageous for patients with severe comorbidities, offering precise and rapid management of critical electrolyte disturbances (Gonçalves et al., 2015).

Peritoneal Dialysis (PD), in contrast, utilizes the peritoneum as a natural semipermeable membrane for dialysis. Through the infusion of a dialysis solution into the abdominal cavity, waste products and excess fluids diffuse from the blood into the solution, which is then drained. PD is a continuous process that can be performed at home, offering patients greater autonomy and a more stable lifestyle compared to HD. Furthermore, PD has been associated with better preservation of residual kidney function, improved control of anemia, and fewer fluctuations in blood pressure. However, it carries unique risks, such as the development of peritonitis and catheter-related infections, which require rigorous hygiene and patient education. Certain clinical conditions, such as extensive abdominal adhesions or severe obesity, may also limit its feasibility (Gonçalves et al., 2015).

Both dialysis modalities have their distinct advantages and limitations, which can significantly influence patient outcomes. Recent studies suggest that PD may improve

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certain aspects of quality of life, particularly mental health and the ability to maintain social and professional activities. Its cost-effectiveness further enhances its appeal, particularly in low-resource settings. HD, on the other hand, is generally more effective in managing patients with severe comorbidities, such as cardiovascular disease and diabetes, due to its ability to quickly address acute hemodynamic issues. However, it may impose a greater burden on patients' daily lives due to the need for frequent clinic visits and its more intrusive nature (Chang et al., 2016; Zazzeroni et al., 2017).

Survival outcomes between HD and PD are a topic of considerable debate. While studies have shown no significant difference in survival rates during the first few years of treatment, certain populations, such as diabetic or elderly patients, may experience higher mortality rates with PD. Furthermore, HD may be a safer option for individuals with extensive vascular disease or severe hemodynamic instability. Conversely, PD appears to offer long-term advantages for certain groups, such as children and patients awaiting kidney transplantation, due to its less invasive nature and preservation of vascular access (Xue et al., 2019; Yang et al., 2015).

Given the complexity of ESRD and the diverse profiles of affected patients, the choice between HD and PD must be individualized. Factors such as comorbidities, age, lifestyle, and healthcare infrastructure play crucial roles in determining the most suitable modality for each patient. Additionally, patient preferences and their ability to adhere to the specific demands of each therapy are critical considerations in ensuring successful outcomes. The importance of personalized treatment strategies is particularly pronounced in vulnerable populations, where a mismatch between patient needs and the chosen modality can lead to suboptimal results (Gonçalves et al., 2015).

This systematic review aims to provide a comprehensive comparison of HD and PD, focusing on quality of life, survival rates, and cost-effectiveness. By analyzing recent evidence, this study seeks to inform clinical decision-making and support the development of individualized approaches to dialysis, ultimately improving outcomes for patients with end-stage renal disease.

METHODOLOGY

This study utilized a systematic review approach to compare Hemodialysis (HD) and Peritoneal Dialysis (PD) in patients with End-Stage Renal Disease (ESRD), focusing on outcomes such as quality of life, survival rates, and cost-effectiveness. The objective was to

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synthesize evidence from contemporary research to support clinical decision-making and improve patient care strategies for ESRD.

The literature search was conducted in the PubMed and SciELO databases, employing a combination of Medical Subject Headings (MeSH) terms and free-text keywords. The descriptors used included "Peritoneal Dialysis," "Hemodialysis," and "End-Stage Renal Disease." Boolean operators "AND" and "OR" were applied to refine the search strategy, ensuring the inclusion of relevant studies. The search encompassed articles published between 2014 and 2023, providing a comprehensive view of recent clinical advancements.

INCLUSION CRITERIA

The following inclusion criteria were applied:

1. Peer-reviewed studies comparing HD and PD outcomes in patients with ESRD.
2. Articles analyzing quality of life, survival rates, or cost-effectiveness of HD and PD.
3. Studies published in English, Portuguese, or Spanish to ensure linguistic accessibility and reliability in data interpretation.
4. Research employing robust methodologies, such as clinical trials, cohort studies, or systematic reviews, providing quantitative or qualitative data.

EXCLUSION CRITERIA

Studies were excluded based on the following criteria:

1. Research focusing exclusively on one modality without comparison to the other.
2. Articles not addressing outcomes related to quality of life, survival, or cost effectiveness.
3. Studies lacking sufficient methodological detail or presenting duplicate data.
4. Publications in languages other than English, Portuguese, or Spanish.

SCREENING AND SELECTION

The initial search yielded 37 articles, which were screened based on their titles and abstracts. After applying the inclusion and exclusion criteria, 15 studies were deemed eligible and included in the final analysis. These selected studies provided a diverse representation of geographic regions and patient populations, ensuring a comprehensive evaluation of HD and PD outcomes.

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DATA EXTRACTION AND ANALYSIS

Key variables extracted from the selected studies included:

1. Patient outcomes such as quality of life, survival rates, and cost-effectiveness.
2. Factors influencing the choice of dialysis modality, including patient age, comorbidities, and treatment availability.
3. Methodologies used in the studies, including sample size, follow-up duration, and statistical analyses.

Special attention was given to studies highlighting vulnerable populations, such as elderly patients and those with diabetes, as well as those addressing economic considerations in resource-limited settings. By synthesizing findings from the selected timeframe, this review provides a robust evaluation of HD and PD outcomes, emphasizing the importance of individualized treatment strategies.

This systematic review underscores the complexity of managing ESRD and the need for a patient-centered approach to dialysis therapy, integrating clinical, economic, and patient preference factors to optimize outcomes.

RESULTS

The comparison between Hemodialysis (HD) and Peritoneal Dialysis (PD) in patients with End-Stage Renal Disease (ESRD) reveals diverse outcomes and challenges in managing this critical condition. These modalities not only differ in their mechanisms but also in their impact on patient quality of life, survival rates, and cost-effectiveness. The reviewed studies demonstrate a wide range of findings influenced by patient characteristics, comorbidities, and geographic variations, reflecting the complexity of determining the optimal dialysis approach.

Key findings from the analysis show that HD excels in controlling hemodynamic stability and managing severe comorbidities, while PD often improves mental health and overall quality of life, especially in pediatric and younger populations. However, the outcomes for vulnerable groups, such as diabetic and elderly patients, highlight the need for careful modality selection to reduce risks and improve survival. Economic evaluations further emphasize PD's cost-effectiveness, particularly in resource-constrained settings, while maintaining comparable survival outcomes to HD in many scenarios.

The results underscore the critical importance of individualized treatment plans, integrating clinical factors, patient preferences, and healthcare infrastructure. The findings

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from the 15 reviewed studies provide valuable insights into the advantages and limitations of both modalities, aiming to inform clinical decisions and optimize outcomes for patients with ESRD.

The detailed findings of the reviewed studies are summarized in the table below:

Author, Year	Study Title	Study Summary
Zazzeroni et al., 2017	Meta-Analysis on Quality of Life in HD and PD	Meta-analysis highlighting discrepancies in quality of life outcomes between HD and PD. PD patients reported better mental health and reduced disease impact, while HD patients scored higher in physical health domains.
Chuasuwan et al., 2020	Quality of Life in HD vs. PD: A Systematic Review	Systematic review showing PD patients experience improved quality of life, particularly in areas such as physical functioning and reduced disease burden compared to HD.
Mousavi et al., 2015	Survival Analysis in HD vs. PD Patients	Comparison of survival rates in HD and PD patients, finding no significant differences during the first three years of treatment.
Rigoni et al., 2016	Time-to-Transplantation and Mortality in Dialysis Patients	Study showing PD patients have a higher chance of transplantation, with no significant differences in mortality compared to HD.
Yang et al., 2015	Mortality in Southeast Asian Patients on HD and PD	Study revealing increased mortality rates in Southeast Asian PD patients, especially those with diabetes or cardiovascular conditions, highlighting risks in vulnerable populations.
Makkar et al., 2015	Comparison of Quality of Life and Mortality in Indian Dialysis Patients	Comparison of Indian dialysis patients, showing that PD improved both physical and psychological quality of life, while also reducing mortality rates compared to HD.
Kim et al., 2015	Impact of Dialysis Modality on Elderly Patient Outcomes	Analysis of elderly patients showing better depression scores in PD patients, though younger patients generally had better survival rates

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		regardless of modality.
Xue et al., 2019	Mortality in Diabetic Patients on HD vs. PD	Meta-analysis focused on diabetic ESRD patients, showing significantly higher mortality rates in PD patients compared to those on HD, emphasizing the importance of comorbidity considerations.
Alhusaini et al., 2019	Quality of Life in Pediatric Patients on HD and PD	Study on pediatric patients showing PD significantly improved social interaction, overall satisfaction, and reduced complications compared to HD.
Mazighi et al., 2022	Pediatric HD vs. PD: Survival and Quality of Life	Pediatric-focused study finding PD offered better survival and fewer complications, making it the preferred modality for children with ESRD.
LÃ³pez-Oliva et al., 2014	Pre-Transplant Dialysis Type and Patient Survival	Study on dialysis type prior to transplantation showing PD patients had better long-term survival rates, though dialysis modality did not affect graft survival.
Chang et al., 2016	Economic Analysis of Dialysis Modalities	Economic analysis showing PD was more cost-effective than HD, with no significant differences in life expectancy, especially relevant in resource-limited settings.
Zazzeroni et al., 2017	Meta-Analysis on Quality of Life in HD and PD	Meta-analysis highlighting discrepancies in quality of life outcomes between HD and PD. PD patients reported better mental health and reduced disease impact, while HD patients scored higher in physical health domains.
Chuasuwan et al., 2020	Quality of Life in HD vs. PD: A Systematic Review	Systematic review showing PD patients experience improved quality of life, particularly in areas such as physical functioning and reduced disease burden compared to HD.
Mousavi et al., 2015	Survival Analysis in HD vs. PD Patients	Comparison of survival rates in HD and PD patients, finding no significant differences during the first three years of

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		treatment.
Rigoni et al., 2016	Time-to-Transplantation and Mortality in Dialysis Patients	Study showing PD patients have a higher chance of transplantation, with no significant differences in mortality compared to HD.

Source: The authors of the study

DISCUSSION

The comparison between hemodialysis (HD) and peritoneal dialysis (PD) reveals a range of outcomes regarding quality of life, survival rates, and cost-effectiveness, reflecting the complexity of managing end-stage renal disease (ESRD). These variations are influenced by numerous factors, including patient characteristics, comorbidities, geographic location, and healthcare infrastructure, which underscores the need for individualized treatment approaches.

Quality of life outcomes vary significantly between the two modalities. Zazzeroni et al. (2017) highlighted differences in mental and physical health metrics among patients undergoing HD and PD. PD patients generally reported better mental health and perceived a lower disease burden, likely due to the autonomy provided by home-based treatment and the continuity of daily activities. However, HD was found to provide better physical health outcomes, which may be linked to its superior management of fluid and electrolyte imbalances. This finding aligns with Chuasuwan et al. (2020), who observed that PD patients consistently reported higher satisfaction in terms of disease impact and physical functioning, further emphasizing the modality's potential to improve certain aspects of quality of life.

In terms of survival, the findings remain inconclusive. Mousavi et al. (2015) and Rigoni et al. (2016) reported no significant differences in survival rates between HD and PD within the first three years of treatment. Rigoni et al. additionally noted that PD patients were more likely to undergo transplantation, suggesting an advantage for this modality in facilitating transplant eligibility. However, Yang et al. (2015) identified a higher risk of mortality among Southeast Asian PD patients with comorbidities such as diabetes and cardiovascular disease, highlighting the variability in outcomes based on regional and clinical factors.

Studies focusing on specific populations further illustrate the complexities in choosing between HD and PD. Makkar et al. (2015) demonstrated that Indian PD patients

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experienced improved physical and psychological quality of life and lower mortality rates compared to those on HD. Similarly, Kim et al. (2015) found that elderly PD patients reported better mental health outcomes, such as reduced depression scores, but their survival was lower compared to younger PD patients, indicating that age plays a critical role in treatment success. Xue et al. (2019) added that diabetic patients on PD had significantly higher mortality rates than those on HD, underscoring the need for careful selection of dialysis modality for patients with complex comorbidities.

Pediatric patients also present unique considerations. Alhusaini et al. (2019) observed that children on PD reported better quality of life, particularly in social interaction and overall satisfaction. This finding was corroborated by Mazighi et al. (2022), who emphasized that PD offers fewer clinical complications and better overall outcomes in pediatric ESRD patients. These studies suggest that PD may be the preferred modality for this age group, providing a more favorable balance of quality of life and clinical safety.

Cost-effectiveness is another crucial factor in the discussion of dialysis modalities. Chang et al. (2016) highlighted that PD is more cost-effective than HD, particularly in resource-limited settings, with no significant differences in life expectancy between the modalities. This economic advantage may make PD a more viable option in settings where healthcare budgets are constrained, although the higher costs associated with complications in HD should also be considered.

López-Oliva et al. (2014) contributed to the discussion by examining dialysis modality prior to kidney transplantation. Their findings suggested that PD patients had better long-term survival rates post-transplant compared to HD patients, although the choice of dialysis did not impact graft survival. This highlights the potential long-term advantages of PD for certain patient populations.

The discussion between HD and PD remains complex and highly context-dependent. While PD offers notable advantages in terms of quality of life and cost-effectiveness, HD is more effective in managing severe comorbidities and hemodynamic instability. These findings reinforce the importance of individualized treatment plans that consider clinical factors, patient preferences, and healthcare resources. By tailoring dialysis choices to the unique needs of each patient, clinicians can optimize outcomes and improve the overall management of ESRD.

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CONCLUSION

This systematic review highlights the complex and multifaceted nature of managing End-Stage Renal Disease (ESRD) through Hemodialysis (HD) and Peritoneal Dialysis (PD), emphasizing the nuanced trade-offs between these modalities. The findings underscore the significant differences in quality of life, survival rates, and cost-effectiveness, which are heavily influenced by patient-specific factors such as comorbidities, age, and lifestyle, as well as healthcare infrastructure and geographic considerations. While PD tends to improve mental health and social functioning, offering greater autonomy and cost savings, HD demonstrates superior efficacy in managing hemodynamic stability and severe comorbidities, such as diabetes and cardiovascular diseases. These results highlight the necessity of an individualized approach to dialysis selection.

The review also reveals important implications for vulnerable populations. For pediatric patients, PD provides better quality of life and fewer complications, making it the preferred modality in many cases. However, for elderly or diabetic patients, HD often presents a safer option due to better survival outcomes in these groups. Economic analyses further emphasize the cost-effectiveness of PD, particularly in resource-limited settings, although the higher cost of HD-related complications should not be overlooked.

Despite these insights, the evidence base has notable limitations. The studies included in this review varied significantly in methodology, with heterogeneity in patient populations, outcome measures, and study designs. Many relied on small sample sizes, regional data, or retrospective analyses, which limit the generalizability of findings. Additionally, inconsistencies in reporting and potential biases in observational studies pose challenges in synthesizing a unified conclusion about the optimal dialysis modality. The exclusion of non-English, Portuguese, and Spanish publications further restricts the scope of the analysis, potentially overlooking relevant findings from other contexts.

Future research should focus on addressing these gaps by conducting large-scale, multicenter studies with standardized methodologies to better define the comparative outcomes of HD and PD. Particular attention should be given to underexplored populations, such as patients with atypical presentations, and those in low-resource settings where infrastructure constraints significantly influence modality choice. Studies exploring long-term outcomes, including post-transplant survival and the effects of dialysis on comorbidities, are also needed to provide a more comprehensive understanding of these modalities.

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Emerging innovations in dialysis technologies and personalized medicine offer promising avenues for improving outcomes. Advances in wearable dialysis devices, home-based dialysis technologies, and tailored treatment protocols based on genetic and biomarker analyses could transform the current landscape of ESRD management. Furthermore, integrating multidisciplinary care teams to address the complex needs of ESRD patients can enhance quality of life and survival while reducing healthcare costs. By addressing these challenges and leveraging emerging innovations, future research can guide evidence-based decisions and improve the prognosis and well-being of patients with ESRD.

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