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Comparison of Hemodialysis and Peritoneal Dialysis Outcomes in the Older Patient Population

Dane Rasmussen
University of North Dakota, dane.rasmussen@und.edu

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Dane Rasmussen, PA-S

Bachelor of Science, University of North Dakota, 2013

Contributing Author:

Mindy Staveteig, MMS, PA-C

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Contributors:

Daryl Sieg, MPAS edu, PA-C

Eric Leveille, MPH

Megan Keely Carroll Denis, MLIS

Nancy Meyer, MSW

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Abstract

The objective of this research and systematic literature review is to determine the dialysis modality of choice for elderly patients with end-stage renal disease. This literature review will compare the outcomes of hemodialysis and peritoneal dialysis, which will be judged by morbidity, mortality, and quality of life. In this review, PubMed, Embase, and DynaMed were searched using a specific set of keywords and mesh headings. Results of the searches were then filtered to include human-only studies, patients over 65 years old, and published within the last ten years. There were 12 studies that met inclusion criteria and were selected for this literature review. The studies suggested that there were similar outcomes in elderly patients receiving hemodialysis and peritoneal dialysis, and it was concluded that dialysis modality selection should be made on an individual patient basis. The choice between hemodialysis and peritoneal dialysis should be made after first considering each patient's goals of healthcare, co-morbid conditions, and life experiences. The dialysis modalities should be discussed between the provider and the patient in detail, and a joint decision regarding dialysis modality selection can then be made. Lastly, barriers should be identified so that they can be overcome with proper education, counseling, and assistance. These steps will allow the older patient to be successful with their selected dialysis modality.

Keywords: hemodialysis, peritoneal dialysis, dialysis, end-stage renal disease, morbidity, mortality, quality of life, elderly

Introduction

In primary care, older adults comprise a large portion of the patient population. The number of elderly patients on dialysis has rapidly increased over the past few decades, especially in developed countries (Segall et al., 2015). As the elderly population continues to age, they become more prone to chronic diseases that frequently result in kidney disease and ultimately end-stage renal disease (ESRD). After ESRD is reached, there are two options to sustain life, renal transplant or dialysis. Often, older patients are not candidates for renal transplant due to advanced age and other comorbid conditions. This often leaves dialysis as the only option to sustain life.

Hemodialysis (HD) and peritoneal dialysis (PD) are the two modalities of dialysis that are most widely used according to Brown, Finkelstein, Iyasere, and Kliger (2017). Hemodialysis consists of running a patient's blood through a dialyzer which allows for the removal of fluid and metabolic waste products from the patient's blood. Typically, these treatments are completed in an outpatient dialysis center with trained healthcare staff. Hemodialysis can also be completed in the patient's own home, but it is not as common. Peritoneal dialysis consists of infusing dialysate solution into the patient's peritoneal cavity and allowing for the diffusion of fluid and metabolic waste products across the peritoneum. The dialysate solution with metabolic waste products is then drained out of the peritoneum and the process is repeated. Peritoneal dialysis is usually completed in the patient's own home, and the patient is often able to complete the peritoneal dialysis treatments independently. HD and PD both have their unique set of benefits and detriments in the older patient population. Understanding each patients' goals of care and life

experiences can help guide the dialysis modality selection for the older patient (Brown et al., 2017).

Statement of the Problem

According to Song and Ward (2014) in the United States, 111,460 new patients with ESRD began dialysis in the year 2010. Of those 111,460 patients, over 50% were over the age of 65 years. In most developing countries, HD is the predominant modality for renal replacement therapy in the elderly ESRD population. Despite HD being the most popular modality for this population, it remains unclear if HD or PD is the modality of choice for this patient population. Comparisons of outcomes in elderly patients receiving HD and PD have mostly relied on observational studies (Segall et al., 2015). There have not been many randomized controlled trials on this subject. It is difficult and possibly unethical to assign patients to a dialysis modality because of the difference in burden associated with each modality (Bieber & Mehrotra, 2015). This literature review will examine the current literature to best determine the dialysis modality of choice for the older adult population.

Research Questions

In older adults (age 65 years and greater) does hemodialysis or peritoneal dialysis provide the best outcomes judged by the quality of life, morbidity, and mortality?

In treating end-stage renal disease with renal replacement therapy in the older adult, is hemodialysis or peritoneal dialysis the modality of choice?

Research Methods

An electronic search of PubMed, Embase, and DynaMed was performed. The internet searches were conducted using the following keywords and mesh headings: renal dialysis, adverse effects, mortality, morbidity, therapeutic use, therapy or trends. Results of the search

were further filtered to include human-only studies, age 65 plus, and published within the last 10 years. Initially, results were filtered to include randomized control studies only. There were not enough results, because most patients are not willing to be randomly assigned to dialysis modalities, because of the profound effects on different lifestyles (Bieber & Mehrotra, 2015). Results were then narrowed to include randomized control studies, peer-review studies, and literature reviews. Studies were further eliminated if they did not pertain to the topic of study.

Review of Literature

Quality of Life on Hemodialysis

Quality of life while receiving dialysis is an important consideration regarding dialysis modality selection in the older patient population. A study by Iyasere et al. (2016) set out to compare the quality of life and physical function of older adults receiving assisted hemodialysis and assisted peritoneal dialysis. The authors used a design that consisted of an observational study of older adults aged 60 or greater that were receiving renal replacement therapy for greater than three months. There was a total of 251 patients in the study (129 PD and 122 HD). The participants in the study that were receiving PD and HD were cross-matched by age, sex, diabetes status, dialysis vintage, ethnicity and, index of deprivation to lower the effects of confounding variables. Inclusion criteria for PD patients were over 60 years of age and being deemed unable to perform home PD without the assistance of a paid healthcare worker or a family member. Inclusion criteria for the HD group included age over 60 years old and requiring hospital transport to attend dialysis sessions. These groups of patients were then assessed with a Hospital Anxiety and Depression Scale (HADS), Short Form-12, Palliative Outcomes Symptom Scale (renal), Illness Intrusiveness Rating Scale, and Renal Treatment Satisfaction Questionnaire (RTSQ). These patients were also evaluated to determine their baseline physical function using

the Barthel Score and timed get up and go test. The two groups were compared to determine if HD or PD supported the best QoL and physical function in the dialysis patient who is 60 years old or greater. Of the 251 total patients in this study, 129 were in the PD group and 122 in the HD group. There was a total of seven patients in the PD group that went unmatched. Of the 251 total patients, 48% met the criteria for frailty based on a frailty score greater than or equal to five. Of the 48% that met the frailty criteria, 51.9% were part of the PD group and 42.6% were part of the HD group. The assisted PD group had higher HADS depression scores and a higher prevalence of possible depression versus HD group (PD 38.8% vs HD 23.8%; P=0.05). However, the RTSQ score was higher in the assisted PD group vs the HD group (PD median:55; IQR, 48-59.75 vs HD median:51; IQR, 44-57; P<0.01). Overall, the results of this study showed that there is no difference in QoL and physical function between older patients undergoing assisted PD and HD. The study did demonstrate that there is higher satisfaction amongst patients undergoing assisted PD vs HD. The study further went on to conclude that older patients should be allowed to make the modality selection between assisted PD and HD based on their preferred choice. This study may have a population bias as the patients were selected from one geographic region in the United Kingdom. Additionally, PD and HD have certain rules and regulations that may differ in other countries which could affect the way patients prefer each modality. The matching process may have increased selection bias because the frailest patients with the shortest life expectancy and patients with significant cognitive impairment were excluded. Lastly, the population size could have been larger, but the retrospective power calculation did suggest that the sample size was large enough to detect associations. Despite some limitations, this study was well designed and compared the quality of life and physical functioning of older adults receiving hemodialysis vs assisted peritoneal dialysis.

The differences in modalities of dialysis may complement different individuals' lifestyles and contribute to a better quality of life for individuals with ESRD who are receiving dialysis. Kang, Do, Lee, and Kim (2017) designed a study to evaluate the differences in Health-related quality of life (HRQoL), frailty, and disability between patients receiving hemodialysis and those receiving peritoneal dialysis. The materials and methods used by Kang et al. (2017) consisted of a multi-center study (27 hospitals or dialysis centers) of ESRD patients receiving maintenance dialysis. Participants recruited had previously enrolled in past studies. Exclusion criteria were age less than 20 years, receiving dialysis for less than six months, past hospitalization within the past three months, unable to walk with or without an assistive device, unable to communicate with the interviewer, refusing to provide informed consent, and not having laboratory findings. A total of 1,616 of the 2,737 total patients met inclusion criteria and were recruited to the study. Once enrolled, demographic and laboratory information was collected including age, sex, comorbid conditions, frailty, disability, and health-related quality of life survey (HRQoL). Multivariate analysis was performed by using analysis of covariance, multivariate Cox regression analysis, or multivariate linear regression analysis. The level of statistical significance was set at $p<0.05$. The results of the study showed that there was no significance in frailty between patients treated with PD vs HD. The mental component scale (MCS) and physical component scale (PCS) scored better in HD patients vs PD patients. Negative symptoms, problems, social interactions, sleep, and social support were favorable in HD patients. It was noted that patient satisfaction and positive dialysis staff encouragement were more favorable in PD patients. The study was well designed and provided statistically significant results regarding the quality of life and physical function of older adults receiving dialysis. However, this study is limited by its retrospective nature being a post-hoc analysis of patients enrolled from previous

studies. Patients included in this study are classified as stable and not representative of the real-world dialysis population. This study was conducted across 27 hospitals and clinics in South Korea, which could contribute to a geographical bias. Lastly, the patients were not randomly assigned to their dialysis modality and they were able to choose between PD and HD which could serve as a confounding variable. It is difficult to randomly assign patients to a modality of dialysis, because it may be considered unethical. Despite these difficulties, the study evaluated the differences in Health-related quality of life, frailty, and disability between patients receiving HD and PD.

Little has been researched regarding the decision-making process when a patient with end-stage renal disease (ESRD) begins dialysis. Song and Ward (2014) investigated whether physicians communicated differently with older patients in comparison to younger patients. Furthermore, this study investigated the perceptions of older and younger patients during the decision-making process when patients selected their modality of renal replacement therapy. The design of the study consisted of a secondary analysis of data from a multi-center randomized control trial. The sample population consisted of 99 patients from 15 outpatient dialysis centers across North Carolina. Inclusion criteria for participants included patients must have been receiving dialysis for at least six months, scored greater than six on the Charleston Comorbidity Index (CCI) or greater than five if they also had a hospitalization within the last six months, were English speaking, and had two or fewer errors on the 10-item Short Portable Mental Status Questionnaire. There were 155 patients eligible to be selected for this study, and 99 consented to participation. Participants were then divided into three groups that were divided by age of the participant (<50 years old, 50-64 years old, and >65 years old). A research staff member conducted telephone interviews that investigated the context of decision making, Informed

Decision-Making (IDM), and perceptions of their decision-making experience. The data was then analyzed and compared amongst the different age groups of participants. The results showed that IDM scores were low across all age groups, but they were lowest for those aged 65 years or greater. The mean (SD) IDM scores for those over 65 years old were 3.63 (2.39), for those between the ages of 50 to 64 years old were 4.67 (1.65), and for patients less than 50 years old they were 4.88 (1.75) ($F=3.86$, $p=0.02$). When the patients were asked about their nephrologist explaining what led to their kidney failure, it was reported that younger patients were much more likely to have their reason for kidney failure explained to them in comparison to patients who were age 65 years old or greater ($x^2=6.46$, $p=0.04$). Younger patients in comparison to older patients were also more likely to have their nephrologist explain to them how daily life might change once starting dialysis ($x^2=6.73$, $p=0.04$), their lifelong need for dialysis ($x^2=10.30$, $p<0.01$) and that the doctor attempted to make sure they understood the information ($x^2=8.63$, $p=0.01$). Furthermore, only one patient over the age of 65 and none of the younger patients in this study were offered palliative care and given the option to not start dialysis. Many patients from each age group did not feel that they had a choice regarding starting dialysis and did not have a choice as to which modality to choose (78.1% age 65 or greater, 66.7% age 50-64 years, and 55.9% age less than 50 years). Lastly, a statistically significant percentage of older patients felt that their decision to begin dialysis was made by their nephrologist rather than their own decision, family decision, or a joint decision with their nephrologist ($p=0.04$). The study had several limitations that may have impacted the validity of the results. This study was conducted across clinics located only in North Carolina and this limited geographic location could have impacted the results. Of the 99 patients in this study, 97 were on hemodialysis and 2 were on peritoneal dialysis which does not give any significant information regarding the differences

among dialysis modalities. Patients were screened for memory impairments with a Short Portable Mental Status Questionnaire but depending on how long the patients have been on dialysis, they may not remember their initial nephrology appointments clearly enough to answer questions accurately. This study only included English speaking participants, which may not contribute to a representative sample. Further information may be necessary to examine the nephrologist's perspective regarding starting dialysis, modalities, and factors affecting their decisions regarding treatment. This study did have many strengths including that it was the first of its kind to address the patient's perception of their role in dialysis modality selection. Furthermore, the study was the first of its kind to examine the difference in physician bias on modality selection with regards to patient age.

The impact of nursing staff bias on dialysis modality selection is not fully understood, but it is important to consider because dialysis nurses spend a considerable amount of direct contact time with ESRD patients. Tennankore, Hingwala, Watson, Bargman, and Chan (2013) set out to investigate this interaction. This study was aimed to investigate if dialysis nurses with different modality expertise would have a difference in opinion regarding one modality over another. Tennankore et al. (2013) used an online survey that was given to all Home Hemodialysis (HHD), Peritoneal Dialysis (PD), and Conventional In-center Hemodialysis (CHD) nurses working at the University Health Network (UHN) in Toronto, Canada. Baseline demographic information was gathered to include age, gender, years of experience, location of nephrology training, and Canadian Nursing Association (CAN) certification. This survey was developed by an HHD physician, PD physician, and nurse practitioner with home dialysis and CHD experience. The survey was written to address five domains which included "choices and influences on modality selection", "patient and system factors that influence modality selection", "benefits of dialysis

location", "dialysis modality mix", and "dialysis education". Questions were written by the panel of medical providers and then were dispersed to five nurse managers from HHD, PD, CHD, vascular access, and pre-dialysis care specialties. These nurses provided anonymous feedback to ensure that the questions adequately covered the domains of interest. The nurse's comments were then reviewed by the physician panel and changes to the questions were made as necessary. The final survey was then dispersed to the dialysis nurses in the UHN. The results of this study showed that dialysis nurses have prevailing views about modality selection that are strongly correlated with their area of dialysis expertise. Of the 129 nurses that were given the online survey, 89 completed or partially completed the survey which resulted in a 69% response rate. The results of the survey were then compared between the CHD, PD, and pre-dialysis clinic nurses. When asked which member of the health care team has the greatest impact on modality selection 87% of home dialysis nurses said it was the physicians, while 57% of CHD nurses said it was the physicians. Furthermore, many dialysis nurses believed that they had the least impact in modality selection (48% home dialysis nurses and 38% CHD nurses). When asked which modality they would choose if they were to require dialysis themselves, they favored the modality of their expertise. Results showed that 80% of home dialysis nurses would favor home dialysis for themselves compared to 52% of CHD nurses. Additionally, of the home modalities, 86% of HHD nurses would prefer HHD for themselves and 79% of PD nurses would prefer PD for themselves. When asked about the proportion of patients receiving CHD it was noted that 85% of home dialysis nurses and 58% of CHD nurses believed that there should be a lower percentage of patients receiving CHD ($p=0.024$). Lastly, all groups of dialysis nurses believed that patients would benefit from further education about dialysis modalities. All groups of nurses also believed that they would benefit from additional education in the form of continuing

education or in-services. This was the first study to compare the opinions of PD, HHD, and CHD nurses towards modality selection. Although the study was well designed and provided the first of its kind information, there were some limitations to this study. This study was only conducted at a single healthcare system in one single geographical area. Furthermore, 129 participants were selected, and the complete response rate was limited to 60.5% and a partial response rate of 69%. This study would have provided more valuable results if all the nephrology nurses in the healthcare system were required to fill out the survey to eliminate participant bias.

It is believed that functional impairment and poor quality of life while on dialysis is associated with poorer dialysis outcomes and higher mortality (van Loon et al., 2017). The authors further researched this matter by comparing the quality of life and its association with mortality amongst various age groups of patients receiving hemodialysis. The study design consisted of a multicenter randomized control trial. This study was called the Convective Transport Study (CONTRAST) which included 714 hemodialysis patients from 29 dialysis centers. The dialysis centers were in the Netherlands (26 centers), Canada (2 centers), and Norway (1 center). This longitudinal study was conducted over the years 2004 to 2010. Inclusion criteria for participants required that patients have end-stage renal disease (ESRD), receiving hemodialysis two to three times per week for at least two months with a Kt/V greater than 1.2 (a marker for dialysis adequacy), and the patients were able to understand the study procedures. Exclusion criteria included patients under the age of 18, historically demonstrated non-compliance with dialysis treatment, life expectancy less than 3 months, or participation in a different clinical trial. Patients were then divided into three groups (<65 years, 65-74 years, and >75 years old). Baseline demographic information was collected as well as a baseline Health-related quality of life (HRQOL). The patients in this study continued to be monitored for quality

of life until their death or the completion of the study in 2010. The data was then analyzed using standard deviations (SD), medians with interquartile ranges or proportions if suitable. Differences between the baseline characteristics were then analyzed with chi-square and ANOVA tests. The results of this study showed that emotional health was higher in the patient population group aged >75 years old compared to the other groups. In contrast, physical functioning was significantly lower in the older patient group in comparison to the other two younger groups of patients. Additionally, a low level of physical functioning, low level of emotional health, and low level of social functioning were all individually associated with increased two-year mortality within each study population. The study was well designed and was one of the first to compare the prevalence of impairment measured by the quality of life among various age groups of dialysis patients as it relates to mortality. There were several limitations noted in this study. The sample population was mostly from the Netherlands which consisted of 26 out of the 29 dialysis centers. The participants were already on hemodialysis (HD) and were not randomly assigned to this dialysis modality. The study excluded patients with a life expectancy of fewer than three months, which likely underestimates the prevalence of impairment. Thus, patients with the poorest health and the greatest risk of mortality were excluded from this trial. Patients with a Kt/V less than 1.2 were also excluded from the trial, which can contribute to a non-representative ESRD patient population.

Quality of Life on Peritoneal Dialysis

Management of older adults on dialysis is best achieved when the wider aspects of aging are addressed in addition to dialysis. It is believed that an individual's goals of care should remain a priority and quality of life may be the ultimate priority in the frail elderly dialysis patient according to Brown, Finkelstein, Iyasere, and Kliger (2016). The goal of this study was to

review the current literature to determine if peritoneal or hemodialysis is the modality of choice for the frail elderly patient. The materials and methods used consisted of a literature review of previous studies to address several nephrology topics. This study investigated the impact of frailty on dialysis outcomes, goals of treatment on dialysis, predicting prognosis, outcomes of HD compared to PD, HD advantages and disadvantages in the elderly, PD advantages and disadvantages in the elderly, and challenges for the health care system. The results of this study showed that there is no one clear answer as to the best modality of dialysis for the frail elderly patient. Many factors may guide modality selection, and it should be a shared decision between the patient and the physician. Furthermore, the decision should be made based on the patient's goals of care, life expectancy, and ideal quality of life. Patient's co-morbid conditions must also play a role in modality selection to prevent exacerbation of certain comorbid conditions. This literature review did a good job comparing HD to PD outcomes in frail elderly patients. It did not indicate how the literature search was conducted and what the inclusion or exclusion criteria were. This study did not include any original research of its own and relied on previous studies to support its claims. There were limited randomized control trial studies used as sources for this study. Several of the studies cited were conducted over ten years ago and might be considered outdated by many.

In a recent study by Segall et al. (2017) the authors compared hemodialysis and peritoneal dialysis outcomes in elderly patients with end-stage renal disease. The study compared HD and PD outcomes to determine the dialysis modality of choice in the elderly patient population. The design of this study consisted of a literature review of the available evidence. This study reviewed previous studies and aimed to address six different topics regarding dialysis in the elderly population. The topics included "timing and strategy of dialysis initiation in elderly

patients with end-stage renal disease", "comparison of advantages and disadvantages of PD and HD in the elderly", "prevalence of PD and HD in the elderly ESRD patient", "survival of elderly patients on PD versus HD", "quality of life in elderly patients on PD versus HD", "risk of peritonitis" and "technique failure in older versus younger PD patients". The results showed that dialysis modality choice should be a patient-centered decision made on an individual patient basis. The decision is best made after the patient has been well informed and can make a well-educated decision. Furthermore, it was found that a greater emphasis should be placed on the promotion of home therapies in elderly patients. There were several limitations to this literature review. There was no method section listed as to how the literature search was performed and what the inclusion or exclusion criteria were. There was no original research performed and there were limited randomized control trials used as sources. There were studies cited that were conducted over ten years ago and might be considered outdated by many.

Morbidity and Mortality on Hemodialysis

It is not fully understood which dialysis modality will provide the best outcomes in older individuals with ESRD who are receiving dialysis but also have other significant co-morbid health conditions. Kan et al. (2013) aimed to understand the outcome predictability in elderly patients receiving dialysis. The authors used the New Comorbidity Index (nCI) which previously showed good predictive value for patient outcomes on chronic dialysis regardless of age. The present study investigated the outcomes of patients age 65 years or greater who were receiving hemodialysis or peritoneal dialysis. The materials and methods used consisted of a population-based cohort study. The authors used Taiwan's National Health Insurance Research Database to gather statistics. The authors searched for patients age 65 years or greater who were receiving maintenance dialysis which was defined as undergoing dialysis for greater than 90 days. This

search yielded 21,043 patients, but eight were excluded because they received a renal transplant before beginning dialysis, which left 21,035 participants in the study. At the start of dialysis, baseline comorbidities were assessed which included diabetes mellitus (DM), hypertension (HTN), congestive heart failure (CHF), coronary artery disease (CAD), cerebral vascular accident (CVA), peripheral artery disease (PAD), other cardiac disease (pericarditis, endocarditis, myocarditis, other complications of the heart disease, heart transplant, heart valve replacement, and cardiac devices), dysrhythmias, chronic obstructive pulmonary disease (COPD), gastrointestinal bleed (GI bleed), liver disease, and cancer. These participants were then divided into four groups of patients based on their nCI score (less than or equal to 3, 4-6, 7-9, and greater than 10). These patients were then further divided by age into 5 sub-groups (65-69, 70-74, 75-79, 80-84, and greater than 85 years old). These patients were then followed for ten years and all-cause mortality and life expectancy were analyzed. Overall, the study demonstrated that the New Comorbidity Index is a strong predictor of mortality in elderly dialysis patients. The lower the nCI score the better the outcome and lower associated risk of mortality. The patients with higher nCI scores are at the greatest risk for poor dialysis outcomes and are at a greater risk for mortality. The nCI scores can determine how to go about customizing the care needed for the individual patient whether it be palliative care or striving for full adequacy of dialysis. During the ten years follow up period, 11,272 or 53.55% of the patients died. The average time alive on dialysis was 4.99 years. The cumulative survival rate of the nCI less than three groups was 88.3% at one year, 28.6% at five years, and 2.0% at nine years. The cumulative survival rate of the greater than ten nCI groups was 75% at one year, 9.3% at five years, and 0.1% at nine years. The difference between the two groups was significant (log-rank: $p<0.001$). In all the age groups, a significantly higher life expectancy was found amongst the

lower scored nCI groups (Kan et al., 2013). Unfortunately, all the participants in this study were from one geographical location which was Taiwan. This study consisted of predominately hemodialysis patients. There were few peritoneal dialysis patients in the study which did not give much information regarding the differences between dialysis modalities. Lastly, this study included a larger number of females than males which could have contributed to gender bias (Females=11,517, males=9,526).

It is not fully understood if hemodialysis, peritoneal dialysis, or conservative treatment will provide the best outcomes in the elderly patient population with ESRD. In a study by Rouveure, Bonnefoy, and Laville (2016) the authors set out to compare the survival outcomes of stage IV and end-stage renal disease patients over 70 years of age who were receiving hemodialysis, peritoneal dialysis, or conservative treatment. The study design consisted of a multi-center longitudinal study that included patients with stage IV and stage V renal disease who were over the age of 70 years old and were part of the pre-dialysis information program in France. Patients were included if they were in the pre-dialysis information program between 1/1/2005 to 12/31/2010. There was a total of 148 patients eligible for this study, and 89 met inclusion criteria. A total of 17 patients were excluded because they had a contraindication for PD, 26 patients were excluded because their kidney functions normalized without dialysis, 4 patients were excluded because they were lost to follow up, and 12 more were excluded because they died before treatment choice was made. The authors compared the survival outcomes of the patients receiving HD, PD, and CT at the start of the program and then longitudinally until 2010. The average age of the participants was 79 years old. In this study 40% of patients were female and 60% of the patients were male. The average eGFR of the participants was 16 + or – 9 at the start of the program. The results of the study showed that the survival of older patients over the

age of 70 years does not seem to depend on their dialysis modality selection. Whether the patient chose HD, PD, or CT the survival was similar in one year. Of the 89 participants, 68 (76%) accepted dialysis, and 21 (24%) chose conservative treatment. Of the 68 participants who elected for dialysis 48 (71%) chose HD and 20 (29%) chose PD. The researchers found that the time for initiation of dialysis was much shorter in the PD group compared to the HD group (146 days vs 442 days; p=0.004). Survival between those that accepted dialysis (HD and PD) and those that refused dialysis (CT) were very similar (749 days or about 2 years in the HD + PD groups vs 562 days or 1 year and 6 months in the CT group; p=0.95). Furthermore, the survival between the PD and HD groups was not statistically significant when compared (p=0.32). This study did a good job comparing the outcomes of PD, HD, and CT in the older patient population. There have been many previous studies that have failed to include CT in their study design, and this study was beneficial to address this option of CT and the outcomes associated. However, the participants were not randomly assigned to HD, PD, and CT which could serve as a confounding variable and thus a limitation to this study design. The sample size of this study was limited to 89 participants. All the participants were from one geographical region which was France. Lastly, 60% of the participants were male and 40% were female which could lead to gender bias.

Morbidity and Mortality in Peritoneal Dialysis

Peritoneal dialysis has certain risks that are unique to the dialysis modality. One of the major risks associated with peritoneal dialysis that is associated with significant morbidity and mortality is peritonitis. Bieber and Mehrotra, (2015) aimed to determine whether there are consistent differences in risk for death in older patients treated with peritoneal dialysis vs hemodialysis. Furthermore, the review aimed to investigate the differences in risk of transfer to HD among older and younger patients receiving PD. The design of the study consisted of a

literature review. It is understood that randomized control trials provide the highest level of evidence, but there are very few studies that have been completed in that fashion regarding this topic because most patients are not willing to be randomly assigned to dialysis modalities. Bieber et al. (2015) compared 26 previous studies to determine which dialysis modality is the best for older patients with ESRD as determined by mortality, and risk for transfer to HD once started on PD. The results of this study showed that none of the differences in risk are large enough to deny patients their preferred dialysis modality. Furthermore, due to insufficient evidence, it is suggested that the patient's autonomy and dignity should be respected regarding their dialysis modality choice. The decision is best to be made after discussions, and education between the patient, caregivers, and physicians. Patients should be allowed to make an informed decision regarding their medical care and modality for renal replacement therapy. This study provided useful information regarding morbidity and mortality across dialysis modalities. Unfortunately, none of the studies in the literature review were randomized control trials, and most of the information was gathered from national registries. The data collected was from single countries or geographical regions, which could contribute to geographical biases.

It remains unclear as to the appropriate choice between hemodialysis or peritoneal dialysis in elderly patients with end-stage renal disease who are at high risk for mortality but have a low chance of receiving kidney transplantation. Han et al. (2015) investigated this problem in a recent study. The study design consisted of a statistical analysis of all elderly Koreans with ESRD receiving dialysis. Data on 13,065 Korean patients age 65 or greater were analyzed (HD n=10,675 and PD n=2,390). Multiple statistical methods were employed including the multivariate Cox model, as well as a meta-analysis of previous studies, and the Korean Health Insurance dataset. Data on all Koreans could be analyzed because Koreans must register

with the national insurance system which encompasses medical aid as well as national health insurance. A total of 35,422 patients were requiring dialysis between January of 2005 and December of 2009 in South Korea, but only 13,065 were 65 age years or greater. Demographic information was collected for each patient in the study including age, sex, type of insurance, and the type of medical center in which the patient was seen. Each patient additionally was scored with the Charlson comorbidity index based on their medical history and data from the year leading up to their initiation of dialysis. These patients were then followed until they received a kidney transplant, passed away, or December of 2009 (maximum of five years). If the patient died within their first three months of starting dialysis they were excluded from the study. For the meta-analysis, there was a search conducted by two separate authors using search terms dialysis modality and mortality or survival. Cochrane and Google Scholar were also searched with the same search terms. Studies published before January of 2000 were not considered and language was limited to English only. Final studies were selected on a consensus basis between the authors, and in the case of disagreement, a third reviewer was utilized. The mean age of participants in this study was 72.2 years old. Of the 13,065 participants, there were 4,939 participants in the 65-69 years old group, 6,650 participants in the 70-79 years old group, 1,418 participants in the 80-89 years old group, and 58 participants in the 90 years old or greater group. The participants in this study were followed for an average of 1.8 years with a maximum of five years. The results of the study showed that patients aged 65 years or greater with ESRD on PD had higher mortality rates than Korean patients aged 65 years or greater with ESRD on hemodialysis ($p<0.001$ by multivariate Cox model). The discrepancy between the HD and PD was greater in the presence of certain co-morbidities such as diabetes mellitus or with a longer duration of time on dialysis. The meta-analysis contained 15 studies which consisted of 631,421

older patients and showed that elderly Korean patients have a higher risk for death if they are receiving PD than those receiving HD. When the meta-analysis was stratified for confounding factors, HD showed even stronger evidence of better outcomes in subgroups that had diabetes mellitus and those who were on dialysis for greater than one year. This study was well designed and included all Koreans receiving dialysis. This was particularly important because it eliminated selection bias. However, the design of this study was observational, which limits the applicability of the results to clinical practice. A randomized control trial would have provided better results, but it is difficult to get patients to agree to be randomly assigned to a dialysis modality. The participants of the observation study were all from South Korea which may result in a geographical bias.

Peritonitis is a major complication of peritoneal dialysis that is associated with significant morbidity and mortality risk among patients receiving PD. Han et al. (2015) investigated episodes of peritonitis with respect to time sequence, microbiology, other factors associated with peritonitis, and clinical outcomes in peritoneal dialysis patients. The materials and methods used consisted of a single-center cohort study of patients with end-stage renal disease (ESRD) who were receiving renal replacement therapy with PD at a North China dialysis center from June of 2012 through June of 2015. Inclusion criteria consisted of age over 18 years old, currently undergoing PD as their modality for renal replacement therapy, stable on PD for at least 90 days, and were followed up regularly at the PD center of the First Teaching Hospital of Tianjin. Patients were excluded if they were missing baseline information, ineligible for PD, refused to participate, were transferred from HD within the last 3 months, or had a previous failed renal transplant. The patients enrolled in this study were followed until they either stopped PD, passed away, or until June 30th of 2017. Data collected during follow up included peritonitis episodes,

hospital admissions with the cause of admission, and cardiovascular events. For each peritonitis episode, they also collected the clinical features of peritonitis, dialysis effluent white blood cell count, dialysis effluent culture results, and the episode of first-ever peritonitis episode. A total of 308 patients received PD catheter insertions between June of 2012 and June of 2015, and 278 met inclusion criteria for this study. The age of the participants ranged from 19 to 91 years old. Conventional PD solutions were used consisting of 1.5%, 2.5% or 4.25% dextrose. Patients used conventional Y connections with double-bag systems. Baseline data was then analyzed and compared regarding peritonitis results. Mean, median, standard deviation, and T-tests were used to analyze the outcomes. The results of the study showed that of the 278 patients enrolled in the study, 136 (48.9%) experienced at least one episode of peritonitis, while 142 (51.1%) did not experience any episodes of peritonitis. Of the 136 peritonitis episodes, 97 episodes were within the first 24 months of dialysis. At the end of the study, there were 218 total episodes of peritonitis recorded. The complete cure, recurrent, relapsing, and repeat rates were 82.4%, 5.1%, 1.5%, and 2.9% respectively. There was a total of 4 or 2.9% of the peritonitis episodes that resulted in death. There were 213 (76.6%) patients hospitalized at least once for non-peritonitis related causes. The peritonitis-free survival rate decreased for each year of the study (75% at year one, 61% at year two, and 49% at year three). Overall, it was found that the cause of most peritonitis episodes was gram-positive organisms associated with touch contamination. Patients with CVD, low potassium, calcium or phosphate abnormalities, those who required assistance, and age younger than 55 years all had a higher association with peritonitis. The time interval to the first episode of peritonitis was associated with the duration of PD treatment, but it did not impact survival. The study investigated peritonitis in detail which is a major risk factor for morbidity and mortality in older patients receiving PD. However, this study took place in North

China at a single dialysis center which can contribute to a geographical bias. The sample size was limited to 278 patients who met the inclusion criteria which limits the strength of the data. The study duration was three years which does not allow for analysis of long-term peritonitis rates and outcomes of PD. Lastly, participants were included only if they agreed to be part of this study which could result in a patient selection bias.

Discussion

Often when older patients are started on dialysis, most nephrologists default to hemodialysis, but there is no great evidence to support this trend. Much research has shown a similar outcome with both peritoneal dialysis and hemodialysis in the older adult population. It is equally important to consider the quality of life and patient preference when selecting the dialysis modality for the older patient (Segall et al. 2017). Understanding each patients' goals of care while considering their life experiences and life expectancy may be a priority in the older patient population (Brown et al., 2016). Patients should be provided with unbiased information and allow the patient and their family to choose the dialysis modality that will best compliment the patients' needs and desires. According to Segall et al. (2017), it is important to also identify barriers that could lead to complications with a modality such as physical, visual, cognitive, psychological, and social problems. Furthermore, these barriers can be overcome with proper education, counseling, and assistance to allow the patient to be successful with their dialysis modality of choice.

In Older Adults (Age 65 Years and Greater) Does Hemodialysis or Peritoneal Dialysis Provide the Best Outcomes Judged by the Quality of Life, Morbidity, and Mortality?

It has been shown that many older patients with ESRD that will require dialysis are often defaulted to incenter hemodialysis, but the data to support that older patients have better

outcomes with hemodialysis vs peritoneal dialysis is lacking. Studies by Iyasere et al. (2016), Kang et al. (2017), and Brown et al. (2017) all support the notion that there is no clear answer regarding the best modality of dialysis for the elderly patient. The studies further concluded that the decisions for initiating dialysis and modality selection should be an individualized choice that is made after discussion between the provider and the patient. It was further concluded that goals of care, life expectancy, and ideal quality of life should be discussed before modality selection. According to Iyasere et al. (2016), there is no difference in the quality of life and physical functioning between older patients receiving assisted PD and HD, but there was higher patient satisfaction with assisted PD vs HD. The conclusion was made that older patients should be allowed to make the modality selection between PD and HD based on their preferred choice. Kang et al. (2017) showed no significance in frailty between patients treated with PD vs HD. According to Segall et al. (2017), dialysis modality selection should be a patient-centered decision that is made on an individual patient basis after the patient has been well informed and can make a well-educated decision. When it came to mortality it was noted by Rouveure et al. (2016) that there is no difference in survival outcomes at one year amongst hemodialysis, peritoneal dialysis, and conservative treatment. The survival outcomes between HD and PD groups were not statistically significant ($p=0.32$).

In Treating End-Stage Renal Disease with Renal Replacement Therapy in the Older Adult, is Hemodialysis or Peritoneal Dialysis the Modality of Choice?

As stated above, the current literature suggests that peritoneal dialysis and hemodialysis provide similar outcomes in the older patient population judged by morbidity, mortality, and quality of life. Each modality has its benefits and detriments, and modality selection should be chosen on an individual patient basis. Choosing a modality of dialysis that compliments the

patient's lifestyle appears to be important. Unfortunately, there is not a lot of data from randomized control trials, because it may be considered unethical to randomly assign patients to a dialysis modality because of the significant effects on each patient's lifestyle. Until further data is collected, it is safe to conclude that PD and HD both provide similar outcomes in the older dialysis patient judged by morbidity, mortality, and quality of life.

Clinical Application

This literature review strives to compare peritoneal dialysis and hemodialysis as it pertains to the outcomes in the older patient population. Primary care clinicians play an important role in educating and managing chronic medical conditions. The primary care clinician must understand the benefits and detriments of each dialysis modality as it pertains to the older ESRD patient. Knowing which modality might be best for their patient, and what struggles their patient may be experiencing is crucial. This review is intended to give the primary care clinician a better understanding of morbidity, mortality, and quality of life associated with older ESRD patients receiving hemodialysis and peritoneal dialysis.

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