REVIEWS

PATIENT AND TECHNIQUE SURVIVAL OF OLDER ADULTS WITH ESRD TREATED WITH PERITONEAL DIALYSIS

Scott D. Bieber and Rajnish Mehrotra

Nephrology, University of Washington, Seattle, WA, USA

The number of older adults worldwide is increasing as societies gain success in improving the health and lifespan of their citizens. As a result, increasing numbers of older adults are presenting to the medical community with advanced kidney failure. Historically, dialysis treatments were withheld from older adults particularly those with severe co-existing illnesses. This has changed in most parts of the world, and there is now an increasing emphasis on shared decision-making to determine whether dialysis is appropriate and to determine which modality meets the needs, expectations, and desire of patients. Evidence examining the difference in risk for death of older adults treated with hemodialysis (HD) or peritoneal dialysis (PD), and the probability of those treated with PD to transfer to HD among older compared to younger adults, is largely derived from prospective cohort studies or analyses of data from national registries. In such studies, it is difficult to distinguish whether differences in outcomes reflect the effect of dialysis modality or differences in health status of different groups of patients. Longevity and technique survival are important, albeit not the only or most important consideration in such decision-making. Given the risk for bias in observational studies and the profound effect of dialysis modality on patients' lifestyle, the selection of dialysis modality should remain a decision made by the patient, caregivers, and his/her physician after thorough education and review of the available data.

Perit Dial Int 2015; 35(6):612-617
<http://dx.doi.org/10.3747/pdi.2015.00050>

KEY WORDS: Peritoneal dialysis; elderly; survival; technique survival; patient survival; mortality.

Discussions about the course of action to take when kidney failure reaches advanced stages in older adults should optimally be informed by well-conducted studies which

compare outcomes between conservative medical management, kidney transplantation, and different dialysis modalities (such as in-center or home hemodialysis [HD] or peritoneal dialysis [PD]). The goal of this current review is to partially inform this decision, using contemporary studies published from 2007 onwards, to determine: (1) whether there are consistent differences in risk for death for older adults treated with PD or HD; and (2) the differences in risk for transfer to in-center HD among older adults treated with PD, compared to younger adults.

Even though randomized controlled trials provide the highest level of evidence to determine whether differences in risk for death among older adults are directly attributable to dialysis modality, no such studies are available. Previous attempts to conduct such trials have been unsuccessful as most patients are unwilling to be randomized to dialysis modalities with substantially different effects on lifestyle. This was evident when investigators from the Netherlands Cooperative Study on Dialysis (NECOSAD) tried to randomize patients to PD or HD, or more recently in the nocturnal arm of the Frequent Hemodialysis Network (FHN) study (1,2). Hence, it is unlikely that clinical trials adequately powered to detect differences in mortality with different dialysis modalities, including in sub-groups of older adults, will ever be available. However, a large number of observational studies have attempted to fill this void by using data primarily from national registries and, to a smaller extent, prospective cohort studies. Similar studies are also available to examine whether the risk for transfer to in-center HD varies by age. Methods vary widely from study to study as do adjustments for confounding. The definition of 'elderly' in studies available for analysis also varies from 55 to 75 years of age, further introducing heterogeneity. Tables 1 and 2 summarize the results of some of the studies available to date. Regardless of the heterogeneity in these studies, it is possible to make some broad generalizations about population-level risk for each of the 2 outcomes that are the focus of this review.

Correspondence to: Scott D. Bieber, Harborview Medical Center, Division of Nephrology, University of Washington, 325 Ninth Avenue, Seattle, WA, USA

scbieber@u.washington.edu

Received 25 February 2015; accepted 4 March 2015.

TABLE 1
Summary Results from Recent Studies Comparing the Risk for Death of Incident Older Adults Treated With
In-Center Hemodialysis or Peritoneal Dialysis

Author, year	World region and cohort period	Study population	Key results
Couchoud 2007 (4)	French REIN registry 2002–2005	3,512 patients (PD: 632; HD: 2,880)	There was no significant difference in 2-year mortality in patients age ≥ 75 years treated with PD and HD; the risk of all patients treated with PD was higher than the sub-group of patients with a planned start of HD
Liem 2007 (5)	Dutch RENINE registry 1987–2002	16,643 patients (PD: 5,802; HD: 10,841)	Generally higher risk for death among older patients treated with PD, compared to HD. Modeled HR (95% CI): 60 yo without DM: 1.05 (0.97, 1.13) 70 yo without DM: 1.16 (1.07, 1.25) 60 yo with DM: 1.29 (1.12, 1.48) 70 yo with DM: 1.42 (1.23, 1.65)
Huang 2008 (6)	Taiwan Renal Registry 1995–2002	48,629 patients (PD: 2,809; HD: 45,820)	Among patients >55 years of age, patients treated with PD had a higher risk for death than those treated with HD (mortality ratio, PD:HD among non-diabetics, 1.31 (1.19, 1.43) and diabetics, 1.99 (1.80, 2.21))
Sanabria 2008 (7)	Colombia 2001–2003	923 patients (PD: 486; HD: 437)	No significant difference in risk for death between patients treated with PD and HD, both in the entire cohort and in the sub-group >65 years of age with or without diabetes
Weinhandl 2010 (8)	United States Renal Data System 2003	12,674 propensity score matched (PD: 6,337; HD: 6,337)	No significant difference in risk for death in individuals ≥ 65 years of age who either started maintenance dialysis with PD or who were treated with PD on day 90, compared to those treated with HD at those respective time points
Mehrotra 2011 (9)	United States Renal Data System 1996–2004	684,426 patients (PD: 64,406; HD: 620,020)	There was a progressive reduction in risk for death among patients treated with PD from 1996–1998 to 2002–2004; in individuals ≥ 65 years of age who started maintenance dialysis between 2002 and 2004, no significant difference in risk for death by modality among non-diabetics but significantly higher risk among diabetics treated with PD compared to HD
Perl 2011 (10)	Canadian Organ Replacement Register 2001–2008	40,526 patients (PD: 7,412; HD: 33,114)	Among individuals ≥ 65 years of age, patients treated with PD had a lower risk for death compared to HD patients that initiated HD with central venous catheter but higher risk for death compared to those with arteriovenous fistula/graft.
Chang 2012 (11)	Taiwan Renal Registry 1997–2006	9,442 propensity-score matched cohort (PD: 4,771; HD: 4,771)	No overall difference in risk for death in patients initiated with PD or HD in 2002–2006; in sub-group ≥ 65 years of age, no significant difference in risk between PD and HD in those with Charlson's comorbidity index <6 , but higher risk for death in those treated with PD with index ≥ 6
Foote 2012 (12)	ANZDATA (Australia, New Zealand Registry) 2002–2005	1,781 patients (PD: 453; HD: 1,328)	Patients age ≥ 75 years treated with PD had a higher risk for death compared to those treated with hemodialysis (HR, 1.26 (1.08– 1.47))
Yeates 2012 (13)	Canadian Organ Replacement Register 1991–2004	46,839 patients (PD: 14,308; HD: 32,531)	No significant difference in risk for death in patients without diabetes treated with PD or HD irrespective of age; higher risk for death for patients >45 years of age with diabetes treated with PD, compared with HD
Haapio 2013 (14)	Finnish Registry for Kidney Diseases 2000–2009	4,463 patients (PD: 1,217; HD: 3,246)	No significant difference in risk for death for patients between 45 and 75 years of age treated with PD or HD; significantly higher risk for death in individuals ≥ 75 years treated with PD, compared to HD
Lee 2014 (15)	Korean Health Insurance Data	11,301 patients (PD: 2,115; HD: 9,186)	Significantly lower risk for death in patients age ≥ 65 years treated with hemodialysis, compared to those treated with PD (HR, 0.75 (0.71, 0.80))

TABLE 1 (cont'd)

Author, year	World region and cohort period	Study population	Key results
Heaf 2014 (16)	Danish Nephrology Registry 1990–2010	12,095 patients (PD: 3,822; HD: 8,273)	Significant improvement in survival of patients treated with PD in 2001–2010 compared to 1990–1999; no significant difference in risk for death in patients ≥ 65 years of age treated with PD or HD
Kim 2014 (17)	Korean Health Insurance Data 2005–2008	14,098 propensity-score matched patients (PD: 7,049; HD: 7,049)	Significantly higher risk for death in patients ≥ 55 years of age treated with PD, compared to those treated with HD (HR, 1.30 (1.20, 1.40))

PD = peritoneal dialysis; HD = hemodialysis; HR = hazard ratio; CI = confidence interval; Yo = year-old; DM = diabetes mellitus.

RISK FOR DEATH

Patients and providers often want to be able to estimate the amount of time they will be able to survive on one modality vs the other. Probability of survival may be most simply informed by data available in national registries such as the United States Renal Data System (Table 3) (3). In 2007, HD patients had a 5-year survival probability of 39.8%, compared with a survival probability of 49.2% in PD patients. In order to understand better the individual risk for death in a given patient, one must delve into the available observational studies listed in Table 1.

A large number of such observational studies have compared the risk for death for older adults treated with PD or HD (Table 1) (4–17). The results of the studies are variable, and the potential reasons for the different results include, but are not limited to, inclusion (or not) of patients treated with PD in the 1990s, the proportion of patients with diabetes mellitus (DM), and the granularity of data available for risk adjustment in statistical models. Data on important factors known to be associated with survival in patients undergoing maintenance dialysis such as race, residual kidney function, serum albumin, body mass index, and pre-dialysis nephrology care are not always available or included for risk adjustment in many of these studies. Moreover, there are likely country-level differences in practices that could potentially account for some of the variability. For example, while in some countries PD is offered primarily to younger and healthier patients, in others older and sicker adults are more likely to be offered PD to maintain them in the home environment. In some countries patients can avail themselves of healthcare provider-assisted PD that allows patients to live in their own homes despite extensive comorbidity.

As in the general population, among patients treated with PD the risk for death increases with advancing age (18–20). Studies from different parts of the world have consistently demonstrated that reduction in mortality in patients treated with PD over the last 2 decades has outpaced improvements seen in patients undergoing HD (11,13,16,21,22). These improvements over time have also been observed among older adults. Consistent with this, the risk for death of patients older than 75 years of age treated with PD in France between 2005

and 2007 was significantly lower than in those treated between 2002 and 2004 (4). It is thus imperative that one considers only studies of contemporary cohorts when examining differences in risk, even for death for older adults treated with PD or HD.

Notwithstanding these differences in the results of the studies undertaken to date, some general conclusions can be made. First, in most parts of the world, in the absence of co-existing DM, there is no significant difference in the risk for death in older adults treated with PD or HD. Second, among older adults with DM the risk for death of patients treated with PD is higher in some countries than with in-center HD. The higher risk in individuals treated with PD may pertain, among others, to risk from systemic effects of obligatory glucose absorption or ability to fine-tune fluid removal, as is often possible with HD, or the presence of severe systemic vascular disease that may have precluded placement of vascular access and mandated treatment with PD. Given the relatively short life expectancy of many older adults undergoing maintenance dialysis, statistically significant differences often translate into only a few months of differences in life expectancy. Finally, and most importantly, it remains unclear whether the differences in risk are directly an effect of the dialysis modality itself and/or related to differences in patients treated with and/or selected for PD or HD.

RISK FOR TRANSFER TO IN-CENTER HD

Transfer from PD to in-center HD can be related to modality-associated complications, patient factors, or system failures. Modality-associated complications include refractory peritonitis or tunnel infections, and catheter malfunction. Patient factors for change of modality include advancing debility following a medical complication such as a stroke, worsening vision, or abdominal catastrophes unrelated to PD. Other social factors such as patient or provider burnout, loss of housing, or change in availability of care provider can also contribute to inability to maintain a patient at home on PD. System-related failures are often due to lack of local PD expertise and services. Unplanned transfer from PD to HD is largely considered undesirable due to a higher risk for the patient to require hospitalization and a central venous catheter for access (23–26). A large number of contemporary studies have

TABLE 2
Summary Results from Recent Large Studies Evaluating Risk of Transfer to In-Center Hemodialysis of Incident Older Adults Treated With Peritoneal Dialysis

Author, year	World region and cohort period	Study population	Key results
Mehrotra 2009 (27)	United States Renal Data System 1996–2004	66,148 patients	Patients ≥ 65 years of age had a 14% higher risk for transfer to in-center hemodialysis compared to individuals 45–64 years of age
Castrale 2010 (18)	French language Peritoneal Dialysis Registry (RDPLF) 2000–2005	1,613 patients (81% on assisted PD)	Patients age >75 years had no significant difference in risk for transfer to in-center hemodialysis with increasing age through ≥ 90 years
Chidambaram 2010 (28)	Ontario healthcare database 1995–2005	5,162 patients	Every 1 year of age associated with 2% higher risk for transfer to in-center hemodialysis
Kolesnyk 2010 (29)	Netherlands Cooperative Study of Dialysis (NECOSAD) 1997–2007	709 patients	Every 1 year older age, associated with 4% higher risk for transfer to in-center hemodialysis
Lim 2011 (30)	ANZDATA Australia and New Zealand Registry 1991–2007	12,932 patients (≥ 65 yrs: 5,176)	Adults ≥ 65 yrs had a significantly lower risk for transfer to in-center hemodialysis compared to younger adults (HR, 0.85 (0.79, 0.93))
Lobbedez 2012 (31)	French Peritoneal Dialysis Registry 2002–2010	9,822 patients (54% on assisted PD)	Every 1 year older age associated with 1% lower risk for transfer to in-center hemodialysis, even when accounting for higher use of assisted PD in older adults
Mehrotra 2012 (32)	On-Call data from Baxter, United States 2004–2009	58,727 patients	Individuals 65–74 and ≥ 75 years of age had a significantly higher risk for transfer to in-center hemodialysis, compared to those between 45–64 years (HRs, 1.14 and 1.21, respectively)
Yang 2014 (33)	National Health Insurance Data, Taiwan 1998–2006	6,928 patients	Every 1 year older age associated with 1% higher risk for transfer to in-center hemodialysis
de Moraes 2014 (34)	BRAZPD 2004–2011	5,707 patients who completed at least 90 days on PD	Individuals ≥ 65 years of age had a significantly higher risk for transfer to in-center hemodialysis
Joshi 2014 (19)	Guangzhou, China 2006–2009	805 patients (≥ 65 yrs, 148)	No significant difference in risk for transfer to in-center hemodialysis by age
Kumar 2014 (35)	Southern California, United States 2001–2010	1,378 patients	For every 10-year increase in age there was a 6% higher risk for transfer to in-center hemodialysis ($p=0.02$)
Pulliam 2014 (36)	Fresenius dialysis facilities, United States 2009	1,677 patients; follow-up through 12 months	No significant association of age with risk for transfer to in-center hemodialysis (HR for transfer to HD every 10 years, 1.06 (0.97–1.16), $p=0.20$)

HR = hazard ratio; PD = peritoneal dialysis; HD = hemodialysis.

examined the differences in risk of older adults treated with PD to transfer to in-center HD compared to younger adults (Table 3) (18,19,27–36). There is variability in the results of studies that have examined the effect of age on risk for transfer to in-center HD. The preponderance of evidence suggests that this risk may be higher in older adults, at least in many different parts of the world. The higher risk in older

adults may relate to higher risk for peritonitis from higher prevalence of limited manual dexterity or visual limitations, or greater likelihood of change in health status (such as stroke or hip fracture) or support system (such as illness in, or loss of, spouse) that may preclude self-care. Where resources exist to assist elderly patients with the provision of PD, either in a long-term care facility or at home, success has been shown in

TABLE 3
United States Renal Data System-Adjusted Probability of Survival Among ESRD Patients by
Months after Initiation of Treatment in 2007 (3)

	3 months	12 months	24 months	36 month	60 months
Hemodialysis (%)	91.4	75.8	63.7	54.2	39.8
Peritoneal dialysis (%)	96.9	87.6	74.9	64.7	49.2

ESRD = end-stage renal disease.

maintaining elderly persons on PD for extended periods of time (18). Furthermore, the geographic differences in relationship of age to risk for transfer to in-center HD may reflect practice patterns as to who is preferentially offered PD or the availability of assisted PD, or the cumulative center experience with providing care to PD patients, particularly in older adults.

CONCLUSION

There is probably no chronic disease that results in as large and persistent impact on a patient's lifestyle as performing maintenance dialysis for the treatment of end-stage renal disease. None of the differences in risk described herein are either large enough or sufficient reason to deny patients their choice of dialysis modality. Hence, in the absence of clear evidence to support better results with a particular dialysis modality in the elderly, it seems most prudent to respect patient autonomy and dignity with regard to modality choice. This decision is best made after iterative discussions between patient, caregiver, and physicians fully informed by some of the data presented herein.

KEY POINTS

- There have been greater improvements in mortality for patients treated with PD than for those treated with HD in many different parts of the world.
- The preponderance of evidence from contemporary studies shows that, in older adults without diabetes, PD and HD provide equivalent survival; in patients with diabetes, there is a higher risk for death in older patients treated with PD in some but not all parts of the world.
- Recent studies show that older adults treated with PD have a higher risk for transfer to in-center HD than younger patients in many different parts of the world.
- None of these studies should affect decision-making for an individual patient as the effect of dialysis modality on lifestyle and quality of life is often much more important to older adults.

REFERENCES

1. Korevaar JC, Feith GW, Dekker FW, van Manen JG, Boeschoten EW, Bossuyt PM, *et al.* Effect of starting with hemodialysis compared with peritoneal dialysis in patients new on dialysis treatment: a randomized controlled trial. *Kidney Int* 2003; 64(6):2222–8.
2. Rocco MV, Lockridge RS Jr, Beck GJ, Eggers PW, Gassman JJ, Greene T, *et al.* The effects of frequent nocturnal home hemodialysis: the Frequent Hemodialysis Network Nocturnal Trial. *Kidney Int* 2011; 80(10):1080–91.
3. United States, Department of Health and Human Services, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, US Renal Data System (USRDS). Annual Data Report: 2014.
4. Couchoud C, Moranne O, Frimat L, Labeuw M, Allot V, Stengel B. Associations between comorbidities, treatment choice and outcome in the elderly with end-stage renal disease. *Nephrol Dial Transplant* 2007; 22(11):3246–54.
5. Liem YS, Wong JB, Hunink MG, de Charro FT, Winkelmayer WC. Comparison of hemodialysis and peritoneal dialysis survival in The Netherlands. *Kidney Int* 2007; 71(2):153–8.
6. Huang CC, Cheng KF, Wu HD. Survival analysis: comparing peritoneal dialysis and hemodialysis in Taiwan. *Perit Dial Int* 2008; 28(Suppl 3):S15–20.
7. Sanabria M, Muñoz J, Trillos C, Hernández G, Latorre C, Díaz CS, *et al.* Dialysis outcomes in Colombia (DOC) study: a comparison of patient survival on peritoneal dialysis vs hemodialysis in Colombia. *Kidney Int Suppl* 2008; (108):S165–72.
8. Weinhandl ED, Foley RN, Gilbertson DT, Arneson TJ, Snyder JJ, Collins AJ. Propensity-matched mortality comparison of incident hemodialysis and peritoneal dialysis patients. *J Am Soc Nephrol* 2010; 21(3):499–506.
9. Mehrotra R, Chiu YW, Kalantar-Zadeh K, Bargman J, Vonesh E. Similar outcomes with hemodialysis and peritoneal dialysis in patients with end-stage renal disease. *Arch Intern Med* 2011; 171(2):110–8.
10. Perl J, Wald R, McFarlane P, Bargman JM, Vonesh E, Na Y, *et al.* Hemodialysis vascular access modifies the association between dialysis modality and survival. *J Am Soc Nephrol* 2011; 22(6):1113–21.
11. Chang YK, Hsu CC, Hwang SJ, Chen PC, Huang CC, Li TC, *et al.* A comparative assessment of survival between propensity score-matched patients with peritoneal dialysis and hemodialysis in Taiwan. *Medicine* 2012; 91(3):144–51.
12. Foote C, Ninomiya T, Gallagher M, Perkovic V, Cass A, McDonald SP, *et al.* Survival of elderly dialysis patients is predicted by both patient and practice characteristics. *Nephrol Dial Transplant* 2012; 27(9):3581–7.
13. Yeates K, Zhu N, Vonesh E, Trpeski L, Blake P, Fenton S. Hemodialysis and peritoneal dialysis are associated with similar outcomes for end-stage renal disease treatment in Canada. *Nephrol Dial Transplant* 2012; 27(9):3568–75.
14. Haapio M, Helve J, Kyllonen L, Gronhagen-Riska C, Finne P. Modality of chronic renal replacement therapy and survival—a complete cohort from Finland, 2000–2009. *Nephrol Dial Transplant* 2013; 28(12):3072–81.
15. Lee S, Ryu JH, Kim H, Kim KH, Ahn HS, Hann HJ, *et al.* An assessment of survival among Korean elderly patients initiating dialysis: a national population-based study. *PloS One* 2014; 9(1):e86776.
16. Heaf JG, Wehberg S. Relative survival of peritoneal dialysis and haemodialysis patients: effect of cohort and mode of dialysis initiation. *PloS One* 2014; 9(3):e90119.
17. Kim H, Kim KH, Park K, Kang SW, Yoo TH, Ahn SV, *et al.* A population-based approach indicates an overall higher patient mortality with peritoneal dialysis compared to hemodialysis in Korea. *Kidney Int* 2014; 86(5):991–1000.
18. Castrale C, Evans D, Verger C, Fabre E, Aguilera D, Ryckelynck JP, *et al.*

- Peritoneal dialysis in elderly patients: report from the French Peritoneal Dialysis Registry (RDPLF). *Nephrol Dial Transplant* 2010; 25(1):255–62.
19. Joshi U, Guo Q, Yi C, Huang R, Li Z, Yu X, *et al.* Clinical outcomes in elderly patients on chronic peritoneal dialysis: a retrospective study from a single center in China. *Perit Dial Int* 2014; 34(3):299–307.
 20. Yang X, Yi C, Liu X, Guo Q, Yang R, Cao P, *et al.* Clinical outcome and risk factors for mortality in Chinese patients with diabetes on peritoneal dialysis: a 5-year clinical cohort study. *Diabetes Res Clin Pract* 2013; 100(3):354–61.
 21. Mehrotra R, Kermah D, Fried L, Kalantar-Zadeh K, Khawar O, Norris K, *et al.* Chronic peritoneal dialysis in the United States: declining utilization despite improving outcomes. *J Am Soc Nephrol* 2007; 18(10):2781–8.
 22. Kumar VA, Sidell MA, Jones JP, Vonesh EF. Survival of propensity matched incident peritoneal and hemodialysis patients in a United States health care system. *Kidney Int* 2014; 86(5):1016–22.
 23. Boissinot L, Landru I, Cardineau E, Zagdoun E, Ryckelynck JP, Lobbedez T. Is transition between peritoneal dialysis and hemodialysis really a gradual process? *Perit Dial Int* 2013; 33(4):391–7.
 24. Lorenzo V, Martn M, Rufino M, Hernandez D, Torres A, Ayus JC. Predialysis nephrologic care and a functioning arteriovenous fistula at entry are associated with better survival in incident hemodialysis patients: an observational cohort study. *Am J Kidney Dis* 2004; 43(6):999–1007.
 25. Jaar BG, Plantinga LC, Crews DC, Fink NE, Hebah N, Coresh J, *et al.* Timing, causes, predictors and prognosis of switching from peritoneal dialysis to hemodialysis: a prospective study. *BMC Nephrol* 2009; 10:3.
 26. Panagoutsos S, Kantartzi K, Passadakis P, Yannatos E, Mourvati E, Theodoridis M, *et al.* Timely transfer of peritoneal dialysis patients to hemodialysis improves survival rates. *Clin Nephrol* 2006; 65(1):43–7.
 27. Mehrotra R, Chiu YW, Kalantar-Zadeh K, Vonesh E. The outcomes of continuous ambulatory and automated peritoneal dialysis are similar. *Kidney Int* 2009; 76(1):97–107.
 28. Chidambaram M, Bargman JM, Quinn RR, Austin PC, Hux JE, Laupacis A. Patient and physician predictors of peritoneal dialysis technique failure: a population based, retrospective cohort study. *Perit Dial Int* 2011; 31(5):565–73.
 29. Kolesnyk I, Dekker FW, Boeschoten EW, Krediet RT. Time-dependent reasons for peritoneal dialysis technique failure and mortality. *Perit Dial Int* 2010; 30(2):170–7.
 30. Lim WH, Dogra GK, McDonald SP, Brown FG, Johnson DW. Compared with younger peritoneal dialysis patients, elderly patients have similar peritonitis-free survival and lower risk of technique failure, but higher risk of peritonitis-related mortality. *Perit Dial Int* 2011; 31(6):663–71.
 31. Lobbedez T, Verger C, Ryckelynck JP, Fabre E, Evans D. Is assisted peritoneal dialysis associated with technique survival when competing events are considered? *Clin J Am Soc Nephrol* 2012; 7(4):612–8.
 32. Mehrotra R, Story K, Guest S, Fedunyszyn M. Neighborhood location, rurality, geography, and outcomes of peritoneal dialysis patients in the United States. *Perit Dial Int* 2012; 32(3):322–31.
 33. Yang SF, Liu CJ, Yang WC, Chang CF, Yang CY, Li SY, *et al.* The risk factors and the impact of hernia development on technique survival in peritoneal dialysis patients: a population-based cohort study. *Perit Dial Int* 2015; 35(3):351–9.
 34. de Moraes TP, Figueiredo AE, Campos LG, Olandoski M, Barretti P, Pecoits-Filho R. Characterization of the BRAZPD II cohort and description of trends in peritoneal dialysis outcome across time periods. *Perit Dial Int* 2014; 34(7):714–23.
 35. Kumar VA, Sidell MA, Yang WT, Jones JP. Predictors of peritonitis, hospital days, and technique survival for peritoneal dialysis patients in a managed care setting. *Perit Dial Int* 2014; 34(2):171–8.
 36. Pulliam J, Li NC, Maddux F, Hakim R, Finkelstein FO, Lacson E, Jr. First-year outcomes of incident peritoneal dialysis patients in the United States. *Am J Kidney Dis* 2014; 64(5):761–9.