KEY FACTORS FOR A HIGH-QUALITY PERITONEAL DIALYSIS PROGRAM — THE ROLE OF THE PD TEAM AND CONTINUOUS QUALITY IMPROVEMENT

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The proportion of end-stage renal disease (ESRD) patients on peritoneal dialysis (PD) has increased very fast in China over the last decade. Renji Hospital, affiliated with Shanghai Jiaotong University School of Medicine, is a recognized high-quality PD unit with a high PD utilization rate, excellent patient and technique survival (1-year and 5-year patient survival rate of 93% and 71%, and 1-year and 5-year technique survival of 96% and 82%, respectively), low peritonitis rate and a well-documented good quality of life of the treated patients. We believe that a dedicated and experienced PD team, a structured patient training program, continuous patient support, establishing and utilizing standardized protocols, starting PD with low dialysis dose, monitoring key performance indicators (KPIs), and continuous quality improvement (CQI) are the key factors underlying this successful PD program.

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The prevalence of end-stage renal disease (ESRD) continues to rise in China and worldwide. Peritoneal dialysis (PD) is a well-established modality of renal replacement therapy (RRT) for ESRD patients. Many studies from a number of countries have consistently shown that PD has a survival advantage compared with hemodialysis (HD) patients in the first few years (1). Moreover, the improvements observed in patient and technique survival in PD over the last decade have exceeded those observed in HD (2). PD also has many

other advantages, including cost savings, preservation of residual renal function, relative high quality of life, and greater capacity to serve more ESRD patients due to its lower infrastructure requirements (3). Therefore, PD is the preferred modality of RRT in many dialysis units in China as it can meet the great demand for dialysis treatment of the rapidly increasing ESRD population. In contrast with the steady decline in incident PD use in western countries (4–6), PD utilization is growing very fast in China (7). However, patient outcome is markedly variable among different centers. This article describes our experiences in developing a sustainable and successful PD program.

PD PRACTICE AT RENJI HOSPITAL

Renji Hospital, affiliated with Shanghai Jiaotong University School of Medicine, was one of the first hospitals to adopt PD in China and has run its PD program for 30 years. It is a recognized high-quality PD unit with a high PD utilization rate, excellent patient and technique survival, low peritonitis rate and a well-documented good quality of life of the treated patients (8,9).

PD UTILIZATION RATE

Although no national renal registry is available in China, analyses of local registry data help to gain an understanding of the dialysis status in the country. A report from the Shanghai Renal Registry showed that, as of 31 December 2010, there were 2,035 patients treated with PD in Shanghai, as compared with 459 patients in 1999, and 1,204 patients in 2006 (10,11). The utilization rate of PD among all dialysis modalities was 24.2% in Shanghai in 2010 (10), and even higher in Renji Hospital, as reflected by the fact that more than 50% of new ESRD patients opt for PD as their preferred RRT modality, and 55% of all dialysis patients are treated with PD (unpublished data, Renji Hospital). As shown in Figure 1, the

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number of PD patients at Renji Hospital has continuously increased in the last two decades.

PATIENT AND TECHNIQUE SURVIVAL

Asian PD patients generally enjoy a superior survival when compared to western PD patients (12,13). Our previous cohort study showed that the 1-year and 5-year actuarial patient survival was 90% and 64% respectively (8), which compared favorably to that of data from the US Renal Data System (USRDS) and many other reports, especially in terms of long-term survival (14–17). In a more recent cohort of 339 incident PD patients recruited between 1 January 2005 and 31 December 2009, we found an acceptable patient and technique survival rate, even after the inclusion of patients dying or failing PD within 90 days (unpublished data, Renji Hospital). Of these patients, 156 were males, and the mean age of all patients was 55.4 ± 17.2 years. In 77 (23.3%) patients,

Figure 1 — The number of prevalent peritoneal dialysis (PD) patients at PD center of Renji Hospital, 1985–2011.

the renal failure was caused by diabetes mellitus (DM), or DM was a comorbid condition. All patients were dialyzed only with traditional glucose-based PD solutions. Patient and technique survival curves are shown in Figure 2. Compared to reports from other units (Table 1), the PD outcome in Renji appears best-in-class with 1-year and 5-year patient survival rates of 93% and 71%, and 1-year and 5-year technique survival of 96% and 82%, respectively. Advancing age, low serum albumin level and cardiovascular comorbidity were independent predictors of mortality in our patients (Table 2).

PERITONITIS RATE

With the improvement in PD connectology and the now exclusive use of the twin-bag system, as well as a strong focus on training and continuous quality improvement (CQI), we have achieved a very low peritonitis rate. In the 1990s when using a disconnect system, the peritonitis rate was around one episode every 24 patient-months. The rate gradually improved to one episode every 56 patient-months after the introduction of the twin-bag system (22). With further focus on training and the application of CQI, the peritonitis rate improved to 1:60.6 patient-months in patients starting PD during 2000–2004 (8), and 1:62.5 patient-months in the 2005–2009 cohort (unpublished data, Renji Hospital).

QUALITY OF LIFE

Many of our patients are elderly. However, we have shown that although physical functional status of older PD patients is inferior to that of younger patients, their psychological functional status is as good as their younger counterparts (9).

Figure 2 — Patient and death-censored technique survival of 339 incident peritoneal dialysis patients recruited at Renji Hospital between 1 January 2005 and 31 December 2009. PD = peritoneal dialysis.

TABLE 1
Patient and Technique Survival in Peritoneal Dialysis at Renji Hospital Compared to Other Reports

Study/Ref	Location	Patients (n)	Patient characteristics		Patient survival rate (%)				Technique survival rate (%)*			
			Age (years) mean±SD	DM (%)	1-yr	2-yr	3-yr	5-yr	1-yr	2-yr	3-yr	5-yr
The present study	China	339	55.4±17.2	23.3	93	88	82	71	96	94	92	82
Yang <i>et al.</i> , (2011) (18)	China	841	48.1±15.9	22.9	94	87	83	—	98	95	91	—
Li <i>et al.</i> , (2008) (13)	Hong Kong, China	328	57.6±13.9	38	—	91	—	—	—	82	—	—
Han <i>et al.</i> , (2007) (19)	Korea	1,656	48.9±14.1	27.8	93.4	—	81.5	69.8	94.9	—	83.7	71.9
Nakamoto <i>et al.</i> , (2006) (20)	Japan	139	49.6±14.9	—	—	—	—	79.7	93.6	86.4	79.1	68.2
Chung <i>et al.</i> , (2005) (15)	Sweden	106	55.6±14.7	37	94.9	83.0	63.5	—	89.8	65.9	51.9	—
Quirós-Ganga <i>et al.</i> , (2012) (16)	Spain	1,464	55±17	28–28.7	90.3	80	65	47	—	—	—	—
Sipahioglu <i>et al.</i> , (2008) (21)	Turkey	423	46.0±14.3	35.2	96.9	—	83.8	68.8	96.1	—	83.2	67.6
Fang <i>et al.</i> , (2008) (8)	Canada	256	58.8±17.8	27.7	90	79	72	61	92	88	85	73
USRDS, (2011) (14)	USA	—	—	—	85	71	59	40	—	—	—	—
Cueto-Manzano <i>et al.</i> , (2001) (17)	Mexico	627	45.2±18.2	37	85	—	68	50	82	—	61	40

SD = standard deviation; DM = diabetes mellitus; USRDS = US Renal Data System.

* Death-censored technique survival rate.

TABLE 2
Predictors of Mortality on Multivariate Cox Analysis

Factors	HR (95% CI)	p
Age (every 1-year increase)	1.031 (1.011–1.052)	0.002
Serum albumin (every 1g/L)	0.873 (0.823–0.926)	<0.001
Cardiovascular disease*	1.923 (1.029–3.649)	0.04

HR = hazard ratio; CI = confidence interval.

* Cardiovascular disease was defined as a previous history of coronary artery disease, peripheral vascular disease or cerebrovascular disease.

WHY IS PD SO SUCCESSFUL IN RENJI HOSPITAL?

Various inherent patient factors may affect PD patients' outcome, including genetic background, comorbidities,

dietary habits, lifestyle, compliance with treatment, body size, and possibly peritoneal transport characteristics (13). Meanwhile, center factors also play a pivotal role. In our experience, the key factors for achieving excellent PD outcomes include: a dedicated and experienced PD team, a structured patient training program and continuous patient support, establishing appropriate protocols, starting PD with a low dialysis dose, monitoring key performance indicators (KPIs), and establishing CQI programs.

A DEDICATED AND EXPERIENCED PD TEAM

The primary driver for the growth of a PD program is the confidence and commitment of the PD team. Indeed, PD is a team effort where each member is essential for success. The PD team at Renji unit consists of five nephrologists and three dedicated PD nurses. The nephrologists have

3–18 years of PD experience, and all practice general nephrology in parallel with PD care. The nurse to patient ratio is 1:125 at our center. The same team of doctors and nurses takes care of both outpatients and hospitalized PD patients. Consequently, we follow our patients from pre-dialysis education, catheter insertion, training, and initial PD prescription to long-term follow-up and complication management. The nephrologists in our center are all engaged in clinical PD research, and play leading roles in the program. They devote sufficient time for overseeing the planning, organization and direction of the program. Nephrologists also work together with the local hospital administration to ensure that both the need for adequate infrastructure for training and care of patients, as well as adequate training of the staff is provided. The dedicated PD nurses contribute the core of the PD program, and act as a liaison with other members of the team to ensure continuous care and coordination. Involvement of a surgeon who knows the unique needs of ESRD patients is also one of the contributors to the success of our PD program. The roles of the surgeon include consultation and management of surgical complications such as hernia repair, laparoscopy catheter insertion for complicated patients, etc.

Center-related factors likely also contribute to achieving good outcomes. Huisman *et al.* reported that having less than 20 PD patients in a center, or having a small fraction of patients on PD, carries an increased risk of technique failure (23). The Renji center has a big PD program, and the high patient volume is possibly associated with the availability of special medical expertise and the extensive experience in PD. In our center, peritoneal catheter insertion and removal are mostly performed by appropriately trained and experienced nephrologists in a dedicated renal operation room with excellent results, which helps in reducing unnecessary surgical consultations and facilitates timely interventions. Nephrologists are, indeed, reported to be ideally suited to perform catheter insertion with excellent catheter outcome data, because of their better understanding of renal patients and the pathophysiology of the disease process (24). The Renji center has organized and hosted national PD Continuing Medical Education (CME) courses annually since 1997 to share our experience in PD. Moreover, retraining of the Renji PD staff also occurs to ensure our skills and knowledge are maintained and renewed. We are encouraged to update ourselves by attending local continuous education and regional and international seminars at least twice every year. The seminars also provide an excellent opportunity for interaction between Renji staff and others in the renal field to share new ideas for better management of patients.

A STRUCTURED PATIENT TRAINING PROGRAM AND CONTINUOUS PATIENT SUPPORT

Successfully maintaining patients on PD requires disciplined and ongoing patient education and support. We have established a well-designed patient training program incorporating real-life problem-solving techniques, and implemented training practices based upon adult-learning principles, which have been shown to reduce exit-site infections, improve fluid balance, compliance and decrease dropout (25). In our center, the dedicated PD nurse is the trainer and, if applicable, both the patient and his/her family or caregivers are learners. In around 10% of patients, PD is implemented by their family members at home. The other advantage of training patients' families is that in the case of patients being unwell, their family members can do PD exchanges for them. It has been shown that the presence of dedicated training nurses can reduce the risk of peritonitis (26). All patients in our center are admitted for training, and the training duration normally is four to five days. We use standardized easy-to-read materials written in simple language and short sentences in an uncluttered format, with a font large enough for easy reading, and with simple pictures. Hands-on-training aids, such as a mannequin or training apron with a PD catheter are used for training and practice. For automated peritoneal dialysis patients, we train both automated peritoneal dialysis and continuous ambulatory peritoneal dialysis (CAPD) techniques. Before patients are sent home, a post-training test for the patient will be completed to carefully determine if the training objectives have been met. In our center, retraining is carried out after every episode of peritonitis, catheter infection, prolonged hospitalization, any other interruption in PD, or periodically according to International Society for Peritoneal Dialysis recommendations (27). Retraining includes re-education of connection procedures, infection control, contamination risks, and medication compliance. Based on a survey, it has been shown that peritonitis rates are significantly lower in centers performing retraining compared to centers that do not (28).

During follow-up, we conduct continuous monitoring and provide support to our patients through: 1) Monthly PD clinic visits, including physical and blood examination, and prescription adjustment when needed; 2) Biweekly PD team meetings and case discussion; 3) A nurse-led and checklist-based telephone follow-up focusing on complication prevention in selected patients such as patients who could not come to the clinic; 4) 24-hour on-call service by the nurses to help patients deal with emergent situations; 5) Home visit for

problematic patients such as a patient having experienced multiple peritonitis; 6) Retraining.

ESTABLISHING APPROPRIATE PROTOCOLS

Establishing appropriate protocols is essential for standardizing PD practice. Accordingly, we have developed center-specific protocols for catheter insertion, patient training, infection control, peritonitis treatment, etc. in our center, all based on available domestic and international guidelines. For example, the protocol for catheter insertion includes: 1) Administration of prophylactic antibiotic at the time of catheter insertion. The International Society for Peritoneal Dialysis guidelines recommend a single intravenous dose of antibiotic at the time of catheter insertion (29,30); cephalosporin or vancomycin is used in our center; 2) Placing the catheter in a downward direction with the superficial cuff 2–3 cm from the exit site, as this has been shown to reduce the risk of exit-site/tunnel infections (31); 3) Catheter function is tested by filling and draining PD fluid before tunneling the catheter; 4) Bowel preparation to avoid constipation before and after surgery, as constipation is associated with catheter malfunction and Gram-negative peritonitis (32); 5) Appropriate catheter care after insertion, including anchoring the catheter to immobilize the exit site and minimize entry of bacteria into the tunnel track. In our center, all catheter implantations adhere strictly to a standardized protocol. In a recent analysis (33), we showed that, during 2001–2010, a total of 657 catheters were inserted. Among them, 37 (5.6%) patients developed catheter-related complications, only 8 (1.2%) needed surgical intervention, and 10 (1.5%) had to be transferred to HD due to catheter dysfunction; others recovered with conservative treatment. In our opinion, establishing standard protocols and strict adherence to them is essential for an optimal outcome of catheter insertion, as well as a high technique survival.

STARTING PD WITH LOW DIALYSIS DOSE

Starting PD with low dialysis dose has been our practice for many years, i.e., most patients start PD with a 3×2 L/24 h regimen, even if our patients initiate dialysis relatively late with an average residual renal function (RRF) of 3.5 mL/min/1.73 m² body surface area (BSA) (8). With this regimen, patients can achieve a mean total Kt/Vurea of 2.2 (8). We previously compared the PD practice pattern and outcomes between our center and a Canadian center. In that study, during the first four years on PD, the majority of patients in our center were dialyzed with three 2-liter CAPD while the Canadian patients were dialyzed

with a much higher dose. However, the patient survival was identical between the two cohorts. Furthermore, our patients enjoyed a significantly higher technique survival as well as a lower peritonitis rate (8). Similar results have been reported from Hong Kong, where, despite a significant lower total small solute clearance, the patient survival rate of patients undergoing three exchanges of CAPD was comparable to that of patients receiving four exchanges of CAPD (34,35). In addition to saving costs and time, the lower dose might theoretically imply a reduced risk of dialysis-related complications including hyperglycemia, obesity, peritonitis, and even encapsulating peritoneal sclerosis (36). In addition, compliance with treatment may be enhanced, as it has been reported that there were significant differences in compliance with different CAPD regimens, with regimens above four exchanges per day found to be an independent predictor for non-compliance (37). We recently investigated the impact of the dose of PD on RRF in incident CAPD patients in a randomized controlled trial. In this study we found that urine output declined slower in the first six months on PD in patients dialyzed with 3×2 L than with a 4×2 L regimen, and indeed, it has been argued that the lower glucose uptake from the dialysate during this period might be beneficial for the preservation of RRF (38). Thus, starting PD with a small dose, followed by an incremental increase when needed, might be one of the contributors to the positive outcome of our program.

MONITORING KEY PERFORMANCE INDICATORS (KPIs), AND ESTABLISHING CONTINUOUS QUALITY IMPROVEMENT (CQI) PROGRAMS IN PD PRACTICE

A KPI is a term for a type of measure of performance. KPIs are commonly used to evaluate the success of a particular activity, providing a benchmark to be met or exceeded. KPIs should be achievable and allow for inter- and intra-unit comparisons. Measuring KPIs is an essential component of PD practice and is necessary for benchmarking, performance improvement and better clinical outcomes. For example, applying CQI principles to clinical practice has been shown to significantly reduce PD-related infection rates (39,40). CQI programs should be established, including regular reporting of outcomes, and become a natural part of everyday work to an extent that it becomes ingrained within the culture of a PD unit. In 2005, we started regular CQI meetings to evaluate root causes of problems and subsequent plans for intervention. Committed and passionate team members as well as active involvement of the entire team are crucial to a successful CQI program. In our center, the lead PD nephrologist decides which aspect requires improvement.

To determine the effect of CQI, we compared patient characteristics and outcomes of patients initiating PD in two consecutive periods. All ESRD patients who started PD between 1 January 2000 and 31 December 2009 were included in the analysis. During this period, a total of 598 patients were enrolled, 259 started PD in 2000–2004, and 339 in 2005–2009. The patient survival rates were: 90%, 79%, 72% and 64% for the 2000–2004 cohort (8) and 93%, 88%, 82% and 71% for the 2005–2009 cohort after 1, 2, 3 and 5 years, respectively (unpublished data, Renji Hospital). Technique survival rates were 96%, 94%, 92% and 82% after 1, 2, 3 and 5 years respectively for the patients who initiated PD in 2005–2009. Compared to the previous cohort, patient survival of the patients from the 2005–2009 cohort improved significantly (Log

rank 5.547, $p = 0.019$) and technique survival remained excellent (Figure 3). Worth noting is that the prevalence of diabetes was significantly higher in the latter cohort (23.3% vs 15.8%, $p = 0.028$) (Table 3).

CONCLUSION

In summary, the Renji PD unit is a high-quality PD center with excellent patient outcomes. We believe that a dedicated and experienced PD team, a structured patient training program, continuous patient support, establishing and utilizing standardized protocols, starting PD with low dialysis dose, monitoring KPIs, and CQI constitute the main factors underlying this successful PD program. With the availability of new technology and

Figure 3 — (A) Comparison of patient survival rates in incident peritoneal dialysis patients between 2000–2004 ($n=259$) and 2005–2009 cohort ($n=339$) in Renji Hospital ($p=0.019$). (B) — Comparison of technique survival rates in incident peritoneal dialysis patients between 2000–2004 ($n=259$) and 2005–2009 cohort ($n=339$) in Renji Hospital ($p>0.05$).

TABLE 3
Comparison of Baseline Patient Characteristics Between 2000–2004 Cohort and 2005–2009 Cohort

	Year of PD initiation		P value
	2000–2004	2005–2009	
<i>n</i>	259	339	
Male (%)	111 (42.9%)	156 (46.0%)	NS
Age (year)	55.2±16.4	55.4±17.2	NS
BMI (kg/m ²)	22.1±3.5	21.7±3.4	NS
Comorbidities			
Diabetes	40 (15.8%)	77 (23.3%)	0.028
Cardiovascular disease	45 (17.8%)	56 (17.0%)	NS
Serum albumin (g/L)	34.5±5.8	34.5±5.2	NS
Hemoglobin (g/L)	94.4±20.7	104.3±22.6	<0.001
Residual renal function (mL/min/1.73 m ²)	3.26 (0, 14)	3.54 (0, 15.07)	NS
Corrected calcium (mmol/L)	2.34±0.29	2.32±0.24	NS
Phosphate (mmol/L)	1.55±0.60	1.44±0.47	0.024
Intact parathormone (pg/L)	211 (3.90, 1519)	175 (1.13, 1478)	0.085

PD = peritoneal dialysis; BMI = body mass index; NS = not significant.

more biocompatible solutions such as icodextrin, an even better outcome in PD patients is likely to be achieved in the future.

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DISCLOSURE

The authors have no conflicts of interest to declare.

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