Influence of Peritoneal Dialysis Training Nurses’ Experience on Peritonitis Rates

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Background: This study examined the clinical impact of peritoneal dialysis (PD) training nurses regarding Gram-positive peritonitis among incident dialysis patients.

Design, setting, participants, and measurements: This study included 200 consecutive inception PD patients in a single center from September 1999 through April 2003. Effects of PD nurse trainers on the clinical outcomes of Gram-positive peritonitis were evaluated.

Results: A total of 81 patients of 200 incident PD patients (mean age 56.9 yr) developed Gram-positive peritonitis. Mean Gram-positive peritonitis-free time for patients who were trained by nurses with years of experience in the lowest tertile was 58.8 mo, as compared with 47.0 mo in those who were trained by nurses within the intermediate tertile of experience (log-rank test, \( P = 0.044 \)). After adjustment for diabetes and relevant coexisting medical factors, PD trainers’ having \( \geq 3 \) yr of experience, body mass index, and baseline serum albumin were the only independent risk factors for the time to a first Gram-positive peritonitis. Training nurses with \( \geq 3 \) yr of experience was associated with more than two-fold increased likelihood of subsequent Gram-positive peritonitis, with an adjusted hazard ratio of 2.24 (95% confidence interval [CI] 1.14 to 4.41; \( P = 0.020 \)). When the lowest tertile group of trainers was used as the reference group in the Cox proportional hazards regression model, the hazard ratio was 1.94 (95% CI 1.04 to 3.61) for the intermediate tertile and 2.13 (95% CI 1.12 to 4.06) for the highest tertile. Experience of the PD trainers was not predictive of Gram-negative peritonitis.

Conclusions: The finding of negative association between the trainers’ length of time in practice and peritonitis incidence reminds us that active continued learning and applying principles of adult learning might be the answers for the nurses to teach the patients.


The importance of peritoneal dialysis (PD) trainers has been highlighted in the recent International Society of Peritoneal Dialysis recommendations, but there is a dearth of literature data on this aspect in relation to the patients’ outcomes (1,2). To examine the potential impact of PD trainers on peritonitis outcomes more systematically, we performed an observational study of incident PD patients who were undergoing PD training in our unit. Specifically, we tested whether the nurses’ experience is associated with the risk for Gram-positive peritonitis. Better understanding of this patient education process will provide insights into this essential component of PD program.

Materials and Methods

This is a retrospective observational study, in which the study population consisted of all incident adult patients who had ESRD and began PD at our unit between September 1999 and April 2003. Patients were followed up until death or October 30, 2006, at which point data were censored.

PD was performed by means of disconnect systems (Baxter, SpA, Deerfield, IL; and Fresenius Medical Care, Deutschland GmbH, Germany) with lactate-buffered glucose-containing dialysate solutions. Prophylactic antimicrobial cefazolin was routinely administered before Tenckhoff catheter placement with downward directed tunnel. Dialysis was initiated after a break-in period of 4 wk after surgical placement of catheter. In our center, nasal swab screening for Staphylococcus aureus carrier was performed when patients presented with S. aureus peritonitis or exit-site infection. Positive nasal culture was routinely treated with topical mupirocin ointment twice per day for 7 d; adjuvant oral rifampin was used for S. aureus peritonitis according to individual nephrologist decision but independent of the result of nasal swab culture (3).

The standard PD training program was provided by an individual renal nurse, with one nurse training two patients at the same time. No patient selection was made with respect to trainers who provided training on a rotation basis. We define trainers’ experience as the number of years a nurse has been in practice in the dialysis unit. For each new dialysis nurse in our unit, a 6-wk orientation in PD with mentor assignment was regularly arranged, during which the new nurse familiarized him- or herself with all PD procedures. Before a nurse started to be a trainer, a full-time experienced training nurse coached the first patient training course. Structured checklist and unit protocol were provided to nurses, with emphasis on effective teaching environment and concepts about adult learning.
aseptic techniques and steps in exchange procedures, exit-site care, and evaluation of the learners (1). Patient training took place in the dialysis clinic and lasted for 5 h each day on average. The total duration of training was determined by the trainers, who were to make sure that the learners could meet (at a minimum) the objectives of performing all required procedures safely, recognizing contamination and infection, and troubleshooting and listing the appropriate responses. Briefly, the nurses demonstrated the practical exchange skills with explanation of the theory behind each exchange step. Patient would be allowed to practice the procedures (with or without using a doll as teaching aid) after learning all of the steps with confidence. In particular, instruction about thorough hand-washing with complete drying was emphasized during the training. Reading and video teaching materials were provided to patients and/or caregivers, who would also receive individual dietary instructions from a diettian. The ratio of patient to nurse (2:1 ratio) from our unit is the usual practice in Hong Kong with limited staffing level in general. Matching of the two learners was in general not possible for us given the staffing level constraint and patient load. Although one nurse was responsible for training two patients simultaneously within our unit, the pace and the length of training varied between individual learners, depending on their learning process, motor skills, and memory. At the end of training, a test was arranged for individual learners to ensure the training objectives had been met through return demonstration of the learner's skill and oral assessment. In practice, teaching was tailored for each learner as in the case of 1:1 teaching; one patient with slower learning would be taught individually after the first learner completed the training. After the initial home visit during the first month after training, follow-up home visits were not routinely arranged. Although routine evaluation of the peritoneal exchange performance was not adopted in our unit, patients who were in need of retraining were identified by nephrologists and nurse specialists over time. In particular, retraining was invariably mandated when either regular bag exchange was interrupted (e.g., temporary hemodialysis or prolonged hospitalization) or a peritonitis episode was suspected to be related to improper bag exchange technique.

Data were obtained from the patient records and renal replacement therapy registry electronic databases. Written approval was obtained from patients before the commencement of PD. The medical data collected consist of demographic details, marital status, employment status, information about the primary renal disease, range of comorbidities (coronary artery disease, peripheral artery disease, cerebrovascular disease, chronic obstructive airway disease, hepatitis B surface antigen status, and diabetes), and anthropometric data at dialysis initiation. Baseline comorbidity was also assessed at the start of dialysis by the Charlson Comorbidity Index validated for the PD population (4,5). Baseline serum albumin level was measured by means of the bromcresol purple method 1 mo after initiation of dialysis.

In terms of dialysis outcomes, we measured the chance of development of dialysis-related Gram-positive peritonitis. Polymicrobial peritonitis was excluded from analysis because such peritonitis is most probably related to bowel sources. Times to first peritonitis episode were examined using a standard survival method.

Statistical analysis was performed by SPSS for Windows (version 11.5; SPSS, Chicago, IL). All data were expressed as means ± SD for normally distributed data and median or range for skewed data. Base-line differences between groups were assessed by the χ2 test with Yates correction for categorical variables and the t test or Mann-Whitney test for continuous variables, as appropriate. Kaplan-Meier survival curves were plotted to display hypothesized relationships, and the difference between the groups was assessed with the log-rank test. Stepwise multivariate Cox regression proportional hazards model was used to predict hazard of development of dialysis-related peritonitis. Analyses were censored at death, transplantation, and transferal to hemodialysis or other modalities of renal replacement therapy. The dependent variable was the time to a first dialysis-related Gram-positive peritonitis. Hazard ratios (HR) and 95% confidence intervals (CI) were calculated with the Cox models, which were adjusted for covariates that were believed to be potential confounders for the time to the first Gram-positive peritonitis. On the basis of our work and that of others (6–12), variables that were used for modeling were body mass index (BMI), baseline serum albumin level, diabetes status, Charlson Comorbidity Index, and duration of training. All probabilities were two-tailed, and the level of significance was set at 0.05.

Results
A total of 200 incident Chinese patients with ESRD were enrolled in the PD program during the study period. Table 1 provides information on characteristics of the 200 patients in our sample. The study population (mean age 56.9 ± 14.4 yr; range 17.2 to 86.0 yr) was studied over a total observation period of 682 patient-years. The median duration of follow-up was 43 mo. A total of 50% of the patients were male; 47.5% had diabetes, and 12% required helpers for dialysis exchanges. Only 3% of the patients received automated PD. During the observation period, 83 patients died and 33 of them underwent kidney transplantation. The 2-yr patient survival and technique survival rates were 85.4 and 95.8%, respectively.

The average PD training lasted for 5.1 ± 1.5 d. The PD trainers had a median 4.9 yr (range 0.3 to 15.6 yr) of experience. As quantified by the tertiles of trainers' experience, the three groups had a similar case-mix profile at the start of PD (Table 1), although the patients who were trained by the nurse with experience at the lowest tertile had lower serum albumin levels (P = 0.004). Otherwise, the prevalence of diabetes, preexisting cardiovascular disease, cerebrovascular disease, and other comorbid conditions, as measured by the baseline Charlson Comorbidity Index scores, were comparable between the groups.

The overall and Gram-positive peritonitis rates were 27.8 and 57.7 patient-months/episode, respectively. Gram-positive organisms accounted for 48% of all peritonitis episodes. The most frequent gram-positive organisms were S. aureus (33.3%) and coagulase-negative staphylococci (31.9%). For evaluation of the PD outcomes, risk for development of the first Gram-positive peritonitis was estimated with respect to the level of trainers' experience. During the period of observation, 81 (40.5%) patients had developed dialysis-related Gram-positive peritonitis (a total of 142 episodes). The Kaplan-Meier method was used to generate unadjusted estimates of Gram-positive peritonitis-free survival. Time to an initial episode of peritonitis varied with respect to the level of experience of PD trainer (Figure 1). Life-table analysis of mean Gram-positive peritonitis-free time for patients who were trained by nurses with years of experience in the lowest tertile was 58.8 mo, which was better than that for patients who were trained by nurses within the intermediate tertile of experience, who had mean Gram-positive peritonitis-free time of 47.0 mo (log-rank test, P = 0.044). Because there was no significant difference between the intermediate and highest tertiles, we attempted to examine the threshold of trainers' experience above which the risk for Gram-positive peritonitis would greatly increase. A crude analysis was carried out by tabulation of the median time to the first Gram-
positive peritonitis across trainers with various levels of experience. As shown in Figure 2, Gram-positive peritonitis outcomes tended to improve with the years of experience of the nurses up to the level of 3 yr, after which the risk for peritonitis increased. We then re-analyzed Gram-positive peritonitis risk among two groups of patients who were trained by nurses with experience of 3 yr (n = 47) and 4 yr (n = 153). Compared with patients who were trained by nurses with 3 yr of experience, those with trainers of 4 yr of experience carried a lower risk for Gram-positive peritonitis (log-rank test, \( P = 0.0098 \); Figure 3). Technique survival did not differ between the two groups (log-rank test, \( P = 0.56 \)). The cumulative probability of all peritonitis (log-rank test, \( P = 0.61 \)) and Gram-negative peritonitis (log-rank test, \( P = 0.79 \)) did not vary significantly between groups. Furthermore, no significant association was detected between the years of experience and the risk for development of peritonitis secondary to *S. aureus*.

Multivariable Cox proportional hazards model was used to determine the independent effects of trainers’ experience in predicting Gram-positive peritonitis and included terms for BMI, baseline serum albumin level, diabetes, Charlson Comorbidity Index, and length of PD training. From this Cox regression analysis (Table 2), the three independent predictors of Gram-positive peritonitis were trainers’ having ≥3 yr of experience, positive peritonitis across trainers with various levels of experience. As shown in Figure 2, Gram-positive peritonitis outcomes tended to improve with the years of experience of the nurses up to the level of 3 yr, after which the risk for peritonitis increased. We then re-analyzed Gram-positive peritonitis risk among two groups of patients who were trained by nurses with experience of <3 yr (n = 47) and ≥3 yr (n = 153). Compared with patients who were trained by nurses with ≥3 yr of experience, those with trainers of <3 yr of experience carried a lower risk for Gram-positive peritonitis (log-rank test, \( P = 0.0098 \); Figure 3). Technique survival did not differ between the two groups (log-rank test, \( P = 0.56 \)). The cumulative probability of all peritonitis (log-rank test, \( P = 0.61 \)) and Gram-negative peritonitis (log-rank test, \( P = 0.79 \)) did not vary significantly between groups. Furthermore, no significant association was detected between the years of experience and the risk for development of peritonitis secondary to *S. aureus*.

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Experience, BMI, and baseline serum albumin level. Training nurses with ≥3 yr of experience significantly increased the likelihood of subsequent dialysis-related Gram-positive peritonitis, with an adjusted HR of 2.24 (95% CI 1.14 to 4.41; \( P = 0.020 \)). Baseline serum albumin level at 1 mo after initiation of dialysis also independently predicted Gram-positive peritonitis after dialysis therapy (HR 1.92 for every 10-g/L decrease in serum albumin; 95% CI 1.20 to 3.07; \( P = 0.006 \)).

When the trainers were analyzed according to the tertiles of experience, higher experience was associated with progressively increased risk for Gram-positive peritonitis (Table 3). When the lowest tertile group of trainers was used as the reference group in the Cox proportional hazards regression model, the HR was 1.94 (95% CI 1.04 to 3.61; \( P = 0.037 \)) for the intermediate tertile and 2.13 (95% CI 1.12 to 4.06; \( P = 0.022 \)) for the highest tertile.

**Discussion**

In this large study within a general dialysis population that consisted of 200 incident patients who had ESRD and required PD, a strong association was present between the level of experience among PD training nurses and the risk for Gram-positive peritonitis. This is also the first study that we know of to explore the extent to which PD trainers’ experience is associated with peritonitis outcomes. We showed that patients who were trained by nurses with increased years of experience were associated with an increase in risk for Gram-positive peritonitis. The association was not weakened after controlling for diabetes and other potential risk factors for dialysis-related peritonitis. However, no difference in terms of Gram-negative peritonitis was identified among patients with trainers of various levels of experience. Given the results of our study, we have to assume that the risk for Gram-positive peritonitis is more complex than medical factors alone.

Common sense and conventional wisdom suggest that an experienced nurse would be more likely to reduce peritonitis rate than a less experienced nurse. Paradoxically, the opposite was demonstrated. Although our study does not address potential mechanisms of the observed association, several reasons may explain this effect. First, our data may represent a cohort effect, reflecting the substantial secular changes that have occurred in the evolution of our understanding of adult learning theory and curriculum development. More experienced nurses may have less familiarity with the concepts of using scientific principles of adult learning to train PD patients; the misconception that anyone can teach PD has not been recognized until recently (1,13,14). In fact, recent literature about acquisition of skills to provide therapeutic patient education has opened a new science (15). It would be interesting for future studies to evaluate further whether Gram-positive peritonitis-free survival among patients who were trained by nurses with various levels of experience. The rate of event-free survival was significantly higher in patients who were trained by nurses with <3 yr of experience (solid line) than those with ≥3 yr of experience (dashed line). \( P = 0.0098 \) by the log-rank test.

![Figure 2. Distribution of the Gram-positive peritonitis incidence according to the years of experience. Patients (shaded bar) who were trained by the nurses who had between 2 and 3 yr of experience had the longest median time to the first Gram-positive peritonitis.](image)

![Figure 3. Kaplan-Meier survival curves demonstrating the probability of Gram-positive peritonitis-free survival among patients who were trained by nurses with various levels of experience. The rate of event-free survival was significantly higher in patients who were trained by nurses with <3 yr of experience (solid line) than those with ≥3 yr of experience (dashed line). \( P = 0.0098 \) by the log-rank test.](image)
In other words, length of time in practice could have been associated with improved outcomes in many other dimensions of care, which cannot be captured by the counting of Gram-positive peritonitis.

Our findings may not be strong enough to support a call for a change in clinical practice; in any event, the results of an observational study should be used only to suggest areas for further research. Clearly, there are many theories regarding the effect of trainers’ experience on peritonitis outcomes, but they remain speculative. Our research findings, although provocative, cannot prove cause and effect; the question of whether years of experience is an indicator of performance or simply an innocent marker of outdated knowledge remains unanswered.

Potential limitations of our study should be noted. We cannot rule out residual confounding by unmeasured variables in our analysis. In particular, bias could have occurred if there was (unspoken) tendency to assign more senior nurses to train the higher risk patients. This possibility cannot be discounted with certainty in our study, although patients who were trained by the least experienced nurses in our study turned out to have lower baseline serum albumin. We did not further perform subgroup analysis with respect to those with various levels of serum albumin because the number of events in each subgroup would be too limited for meaningful analysis. Despite a trend for patients who were trained by the most experienced nurses to have a shorter training period, we did not see any influence of training duration on the risk for Gram-positive peritonitis when we attempted to explore and clarify this covariate in the univariate and multivariate analysis. There is another caveat to this study. We did not collect information on individual trainers and were unable to ascertain whether particular individuals may have biased results. For instance, we did not know the S. aureus nasal carriage status of individual nurses. Although the prevalence has been reported to be higher among health care workers with longer length of service (23), the re-analyzed risk for S. aureus peritonitis did not differ between the nurses with various levels of experience. A third limitation relates to the external validity. Our observed rates of overall and Gram-positive peritonitis were consistent with those found in longitudinal studies of PD (24–26), suggesting that our findings may be applied in other PD settings. The larger issue, nevertheless, is whether the sample of nurses in our cohort is representative. Also, because the ratio of patient to nurse falls short of the International Society of Peritoneal Dialysis recommended 1:1 ratio (1,27), important questions remain concerning the validity of extrapolating our results to dialysis centers with higher staffing levels. Longitudinal data sets from more than one center will be essential for establishing the generalizability of our findings.

Table 2. Independent predictors of Gram-positive peritonitis according to Cox proportional hazards analysis

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Univariate</th>
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<th>Multivariate</th>
<th></th>
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<tbody>
<tr>
<td>Training nurses with ≥3 yr of experience</td>
<td>2.26 (1.20 to 4.29)</td>
<td>0.012</td>
<td>2.24 (1.14 to 4.41)</td>
<td>0.020</td>
</tr>
<tr>
<td>Baseline serum albumin level (each 10-g/L decrease)</td>
<td>1.50 (0.94 to 2.40)</td>
<td>0.089</td>
<td>1.92 (1.20 to 3.07)</td>
<td>0.006</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.94 (0.61 to 1.46)</td>
<td>0.79</td>
<td>1.18 (0.73 to 1.91)</td>
<td>0.50</td>
</tr>
<tr>
<td>BMI (each kg/m² increase)</td>
<td>1.05 (1.00 to 1.10)</td>
<td>0.063</td>
<td>1.04 (0.99 to 1.10)</td>
<td>0.035</td>
</tr>
<tr>
<td>Charlson Comorbidity Index &lt;4</td>
<td>1.06 (0.61 to 1.84)</td>
<td>0.83</td>
<td>1.29 (0.64 to 2.62)</td>
<td>0.47</td>
</tr>
<tr>
<td>Duration of training (each day increase)</td>
<td>1.01 (0.86 to 1.19)</td>
<td>0.88</td>
<td>0.97 (0.82 to 1.15)</td>
<td>0.73</td>
</tr>
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</table>

Table 3. HR of Gram-positive peritonitis associated with the tertiles of trainers’ experience according to Cox proportional hazards analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Univariate</th>
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<th>Multivariate</th>
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<tbody>
<tr>
<td>Training nurses with ≥3 yr of experience</td>
<td>Reference</td>
<td>—</td>
<td>Reference</td>
<td>—</td>
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<tr>
<td>intermediate tertile</td>
<td>1.82 (1.02 to 3.23)</td>
<td>0.042</td>
<td>1.94 (1.04 to 3.61)</td>
<td>0.037</td>
</tr>
<tr>
<td>highest tertile</td>
<td>1.78 (0.99 to 3.21)</td>
<td>0.054</td>
<td>2.13 (1.12 to 4.06)</td>
<td>0.022</td>
</tr>
<tr>
<td>Baseline serum albumin level (each 10-g/L decrease)</td>
<td>1.50 (0.94 to 2.40)</td>
<td>0.089</td>
<td>1.94 (1.21 to 3.07)</td>
<td>0.006</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.94 (0.61 to 1.46)</td>
<td>0.79</td>
<td>1.25 (0.73 to 2.15)</td>
<td>0.42</td>
</tr>
<tr>
<td>BMI (each kg/m² increase)</td>
<td>1.05 (1.00 to 1.10)</td>
<td>0.063</td>
<td>1.06 (1.01 to 1.12)</td>
<td>0.032</td>
</tr>
<tr>
<td>Charlson Comorbidity Index &lt;4</td>
<td>1.06 (0.61 to 1.84)</td>
<td>0.83</td>
<td>1.17 (0.62 to 2.21)</td>
<td>0.63</td>
</tr>
<tr>
<td>Duration of training (each day increase)</td>
<td>1.01 (0.86 to 1.19)</td>
<td>0.88</td>
<td>1.01 (0.85 to 1.19)</td>
<td>0.95</td>
</tr>
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aCI, confidence interval; HR, hazard ratio.
Conclusion
This study demonstrated a striking negative association between the trainers’ length of time in practice and dialysis-related Gram-positive peritonitis, independent of known risk factors. Despite the lack of solid evidence from well-controlled clinical trials, our observational data should be taken as a wake-up call to the PD society that teaching patients to perform dialysis safely is a daunting task. As acknowledged by a recent article (28), we concur that ongoing active efforts are warranted to maintain competency in teaching PD, which in and of itself might not be acquired passively through accumulating experience. In addition, continuing education of trainers may be beneficial if it is shown that updated courses for the trainers can decrease the risk for Gram-positive peritonitis, a question that has not yet been examined.

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Disclosures
None.

References