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# Impact of patient training patterns on peritonitis rates in a large national cohort study

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ORIGINAL ARTICLE

## ABSTRACT

**Background.** Ideal training methods that could ensure best peritoneal dialysis (PD) outcome have not been defined in previous reports. The aim of the present study was to evaluate the impact of training characteristics on peritonitis rates in a large Brazilian cohort.

**Methods.** Incident patients with valid data on training recruited in the Brazilian Peritoneal Dialysis Multicenter Study (BRAZPD II) from January 2008 to January 2011 were included. Peritonitis was diagnosed according to International Society for Peritoneal Dialysis guidelines; incidence rate of peritonitis (episodes/patient-months) and time to the first peritonitis were used as end points.

**Results.** Two thousand two hundred and forty-three adult patients were included in the analysis: 59 ± 16 years old, 51.8% female, 64.7% with ≤4 years of education. The median training time was 15 h (IQI 10–20 h). Patients were followed for a median of 11.2 months (range 3–36.5). The overall peritonitis rate was 0.29 per year at risk (1 episode/41 patient-months). The mean number of hours of training per day was 1.8 ± 2.4. Less than 1 h of training/day was associated with higher incidence rate when compared with the intervals of 1–2 h/day (P = 0.03) and >2 h/day (P = 0.02). Patients who received a cumulative training of >15 h had significantly lower incidence of peritonitis compared with <15 h (0.26 per year at risk versus 0.32 per year at risk, P = 0.01). The presence of a caregiver and the number of people trained were not significantly associated with peritonitis incidence rate. Training in the immediate 10 days after implantation of the catheter was associated with the highest peritonitis rate (0.32 per year), compared with training prior to catheter implantation (0.28 per year) or >10 days after implantation (0.23 per year). More experienced centers had a lower risk for the first peritonitis (P = 0.003).

**Conclusions.** This is the first study to analyze the association between training characteristics and outcomes in a large cohort of PD patients. Low training time (particularly <15 h), smaller center size and the timing of training in relation to catheter implantation were associated with a higher incidence of peritonitis. These results support the recommendation of a minimum amount of training hours to reduce peritonitis incidence regardless of the number of hours trained per day.

**Keywords:** education, nursing, peritoneal dialysis, peritonitis, training

## INTRODUCTION

Peritonitis remains the most important risk factor for definite transfer of peritoneal dialysis (PD) patients to hemodialysis (HD) and can be associated with mortality rates of up to 5% [1]. Errors related to an incorrect technique exchange by either the patient or the caregiver is an important cause of peritonitis, and adequate patient training is considered an important measure to reduce peritonitis incidence. Nevertheless, data on training methods for patients to prevent peritonitis are lacking. In fact, among the foregoing predictors of peritonitis, technique-related factors can be improved through strengthened training for clinical practitioners and PD patients [2, 3]. Training PD patients requires a coordinated team and a multidisciplinary approach [4]. Patient education is essential to achieve self-care, to enable the patient to maintain a good state of health and to prevent complications, among which peritonitis is a major cause of morbidity and dropout [5, 6].

Nevertheless, the scarce information available from several centers of different countries in this subject is very heterogeneous. No consensus exists about how long the training time should be or the ideal timing or locale of training, making it difficult to define recommendations of particular standards of patient training that would ensure best PD outcome [7]. Therefore, the aim of this study was to describe the training characteristics of PD patients in a large Brazilian cohort and analyze their association with peritonitis incidence.

## MATERIALS AND METHODS

This is a nationwide prospective cohort study launched in December 2004, enrolling centers treating >10 PD patients in Brazil, as inclusion criterion. Once selected for the study, every clinic submitted the research project to the local ethics committee, and after approval, at least one physician and one nurse from the center were trained by study monitors to use the specific data capture software (PDNet). All patients signed an informed consent agreeing to participate in the study and were followed until discontinuation of PD or to the end of the study in January 2011.

This study included all incident adult patients from 122 PD centers reporting monthly by nephrologists and nurses at the PD clinic. Data collection included demographic and clinical variables including age (years), gender, race, cause of end-stage renal disease, previous treatment, PD modality (Continuous Ambulatory Peritoneal Dialysis [CAPD or APD]), body mass index (kg/m$^2$), blood pressure (BP) (mmHg), history and time of pre-dialysis care, family income, education level (more or less and equal to 4 years of total education) and distance from dialysis center (up to 50 or >50 km). Data on training were reported in the study only after January 2008 and comprise date of training, training session duration in hours and number of people trained (individual or group). Individual training was defined as only the patient or one caregiver was trained, and group training when patient/family or next of kin were trained together. The variable training hours per day was defined as the total hours of patient training divided by the total number of days in training; it is considered as contact hour, meaning the amount of time that a nurse spends teaching a patient in a given day and not the amount of time a patient spends in hospital for training. There was no register to indicate whether more than one patient was trained at each time. The time of training was classified as: before catheter insertion, from 1 to 10 days after catheter implantation, or >10 days after catheter placement. The method of training was the standard of care of each unit; in general, training methods in Brazil are based in didactic material provided by industry, verbal instructions on how to perform exchange safely and how to recognize contamination or infection. Center size was defined as the mean number of prevalent patients treated at the study start.

### Statistical analysis

The statistical analysis was performed using SPSS 20.0 and the package cmprsk for R software version 3.0.2. Continuous variables were expressed as mean and SD or median and quartile range, whereas categorical variables were expressed as frequencies and percentages. We analyzed both time to first peritonitis episode and the incidence rate of peritonitis, the latter calculated as the number of peritonitis episodes during the follow-up divided by the total person-months. For comparison of groups, in relation to incidence rate, we adjusted Poisson regression models with the number of peritonitis as the response variable and the factors as explanatory variables. The Fine and Gray competing risk models were used for analysis of time to first peritonitis episode, and the sub-distribution hazard for the first episode was adjusted. One model included age, gender, modality of dialysis and other covariates that presented a P-value of <0.20 in the univariate analysis. Another model was adjusted including only variables that presented P-value of <0.10 in the univariate analysis. The first peritonitis episode was considered the primary event of interest, any cause of dropout of the study before a peritonitis episode was considered a competing risk event and those patients active at the end of the follow-up and without any peritonitis episode were treated as censored. The significance level was set at $P < 0.05$.

## RESULTS

From January 2008 to January 2011, a total of 2243 incident patients with valid data for training from 122 centers were included in the study. Table 1 shows clinical and demographic data of patients included in the analysis. The majority of patients, 1775 (79.1%), had no episode of peritonitis, whereas 468 (20.9%) had at least 1 episode. Overall, there were 736 peritonitis episodes, representing an incidence of 0.29 per year at risk (1 episode per 41 patient-months). The incidence rate of peritonitis stratified by training hours divided in quartiles (10, 15 and 20 h) and stratified by the timing of training related to the catheter implantation (within 10 days, before and after 10 days) is shown in Table 2. However, considering the intervals up to 15 h and >15 h of training, the incidence of

**Table 1. Main characteristics of the study population (*n*: 2243)**

| Variable | Classification | Results[a] |
|---|---|---|
| Age (years) | | 59.4 ± 16.0 |
| Gender | Female | 1162 (51.8%) |
| | Male | 1081 (48.2%) |
| Modality | APD | 1164 (53.7%) |
| | CAPD | 1005 (46.3%) |
| Diabetes | | 920 (41.0%) |
| Type of training | Individual | 1819 (81.1%) |
| | Group | 424 (18.9%) |
| Education level (years) | ≤4 | 1440 (64.7%) |
| | >4 | 786 (35.3%) |
| Distance to center (km) | ≤50 | 1746 (77.8) |
| | >50 | 497 (22.2) |
| Size of center | | 61 (33–87) |
| Length of training (hours) | | 15 (10–20) |
| Hours of training/day | | 1.1 (0.7–2) |
| Time to first peritonitis (months) | | 6 (3–11) |
| Follow-up (months) | | 11.2 (6.1–19.3) |

[a]Expressed as frequency (percent); mean ± SD or median (25–75%).

peritonitis was higher in patients with up to 15 h of training (0.32 per year at risk or 1 episode per 38 patient-months) than patients trained for >15 h (0.26 per year at risk or 1 episode per 46 patient-months, P = 0.01). A subgroup analysis of training patterns stratified by age and literacy showed that the impact of the length of training was relevant to young patients of ≤65 years old (subhazard ratio [SHR]: 0.77, 95% CI: 0.6–0.98, P = 0.0033) and with an education level of ≤4 years (SHR: 0.75, 95% CI: 0.6–0.95, P = 0.011).

The analysis of hours per day of training was based on three intervals: <1 h per day, 1–2 h per day and >2 h per day. The incidence rate for <1 h of training was 0.34 per year at risk (1 episode per 34 patient-months), with significant difference when compared with 1–2 h per day (0.28 per year at risk or 1 episode per 43 patient-months, P = 0.03) or to >2 h per day (0.27 per year at risk or 1 episode per 45 patient-months, P = 0.02). Training APD took longer (mean: 22.2 ± 29.1 h) than CAPD (mean: 16.4 ± 13.1 h) with significant difference (P = 0.027).

For the timing of training, we found difference between patients trained within 10 days (0.32 per year at risk or 1 episode per 37 patient-months) and patients trained after 10 days of the implantation (0.23 per year at risk or 1 episode per 52 patient-months)(P = 0.001). Patients trained before compared with patients trained within 10 days or after 10 days of catheter implantation showed P-values of 0.10 and 0.09, respectively. We further analyzed the incidence rate for other factors such as presence of a caretaker and number of people trained, but no association was found (P > 0.05).

Considering the time to the first episode of peritonitis, we analyzed the cumulative incidence curve of groups defined by age (≤65 or >65 years), gender, diabetes, education level (≤4 or >4 years), distance to center (≤50 or >50 km), length of training (≤15 or >15 h), modality of first month dialysis (APD or CAPD), median size of center (<61 patients or ≥61 patients) and the timing of training related to catheter implantation (within 10 days, before or after 10 days). The multivariate analysis showed that, adjusting for other factors, higher education level (>4 years) and centers with more patients (≥61 patients) were associated with better results (SHR: 0.80; 95% CI: 0.65–0.97 and SHR: 0.75; 95% CI: 0.62–0.90, respectively). Patients trained before the catheter implantation have a more favorable incidence curve for the first episode of peritonitis than patients trained within 10 days of catheter implantation (SHR: 0.77; 95% CI: 0.62–0.90). The same occurs for the patients trained after 10 days of implantation (SHR: 0.71; 95% CI: 0.55–0.92) (Table 3). Cumulative incidence curves for the first episode of peritonitis stratified by education level, hours of training, size of center and the training timing are presented in Figure 1. Adjusting a model only with the variables that presented a P-value of <0.1 in the univariate analysis (education

**Table 2. Incidence of peritonitis according to duration and time of training**

| | Interval (hours) | Number of episodes per patient-months | Number of episodes per year at risk | P-value[b] |
|---|---|---|---|---|
| Length of training (hours) | <10 | 1/39 | 0.31 | 0.097 |
| | 10–15 | 1/37 | 0.32 | 0.021 |
| | 15.1–20 | 1/45 | 0.27 | 0.669 |
| | >20 (ref.) | 1/47 | 0.26 | |
| Hours of training per day | <1 | 1/35 | 0.34 | 0.020 |
| | 1–2 | 1/43 | 0.28 | 0.656 |
| | >2 (ref.) | 1/45 | 0.27 | |
| Training time[a] | Within 10 days (ref.) | 1/37 | 0.32 | |
| | Before insertion | 1/43 | 0.28 | 0.100 |
| | After 10 days | 1/52 | 0.23 | 0.001 |

[a]Related to the catheter implantation.
[b]Poisson regression models, $P < 0.05$.

**Table 3. Multivariate analysis: training and other factors associated with the first peritonitis**

| Variable | Stratification | *n* | P-value[a] (univariate) | P-value[a] (multivariate) | SHR[a] (95% CI) |
|---|---|---|---|---|---|
| Age (years) | ≤65 | 1365 | 0.220 | 0.190 | 0.88 (0.73–1.06) |
| | >65 | 878 | | | |
| Gender | Female | 1162 | 0.610 | 0.550 | 1.06 (0.88–1.27) |
| | Male | 1081 | | | |
| DM | No | 1323 | 0.190 | 0.290 | 1.10 (0.92–1.32) |
| | Yes | 920 | | | |
| Modality | APD | 1164 | 0.540 | 0.220 | 0.89 (0.74–1.07) |
| | CAPD | 1005 | | | |
| Education level (years) | ≤4 | 1440 | 0.032 | 0.025 | 0.80 (0.65–0.97) |
| | >4 | 786 | | | |
| Distance to center (km) | ≤50 | 1746 | 0.077 | 0.180 | 1.15 (0.93–1.42) |
| | >50 | 497 | | | |
| Length of training (hours) | ≤15 | 1342 | 0.086 | 0.064 | 0.83 (0.69–1.01) |
| | >15 | 901 | | | |
| Size of center (patients) | <61 | 1118 | 0.017 | 0.003 | 0.75 (0.62–0.90) |
| | ≥61 | 1125 | | | |
| Training time[b] | Following 10 days (ref.) | 1240 | | | |
| | Before insertion | 581 | 0.010 | 0.020 | 0.77 (0.62–0.90) |
| | After 10 days | 422 | 0.055 | 0.011 | 0.71 (0.55–0.92) |

[a]Gray and Fine model, including death and dropout as competitive risk.
[b]Related to the time of catheter implantation.

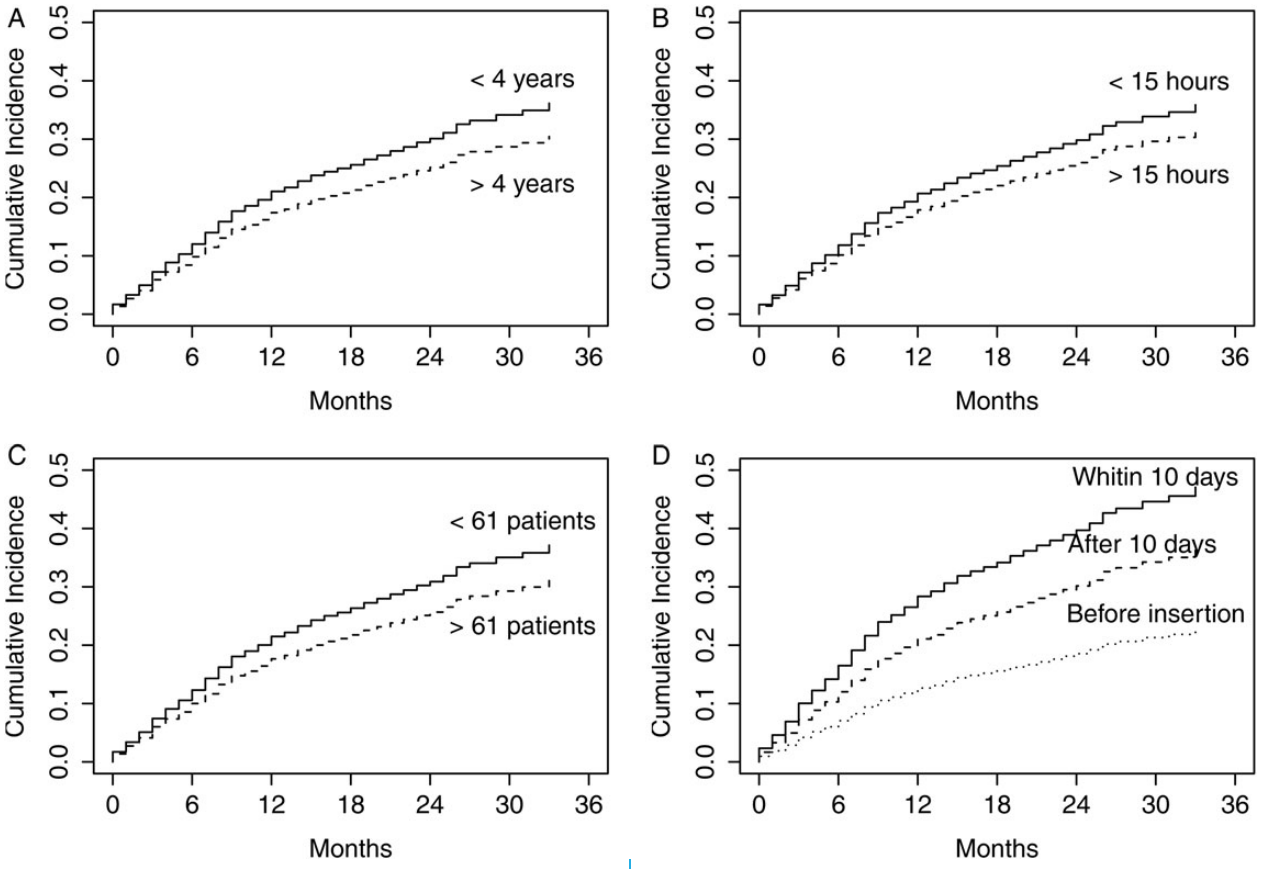


**FIGURE 1:** Cumulative incidence failure for time to first peritonitis according to education level (**A**), hours of training (**B**), center size (**C**) and timing of training (**D**) estimated by Fine and Gray model.

level, distance to center, length of training, size of center and training time), showed significant difference between incidence curves of education level (P = 0.03; SHR: 0.81; 95% CI: 0.66–0.98), length of training (P = 0.04; SHR: 0.82; 95% CI: 0.68–0.92), size of center (P = 0.004; SHR: 0.76; 95% CI: 0.63–0.92) and training time considering following 10 days as reference category (before insertion with P = 0.01; SHR: 0.72; 95% CI: 0.56–0.93 and after 10 days with P = 0.02; SHR: 0.78; 95% CI: 0.62–0.97). No significant difference was observed when curves of distance to center were compared (P = 0.13; SHR: 1.17; 95% CI: 0.95–1.44).

## DISCUSSION

Since PD is a self-care method, models of patient training are an essential part of this renal replacement therapy modality; however, there is paucity of studies in the past to determine the impact of training variations on hard outcomes. This is the first large cohort study to show a benefit of longer time of training on peritonitis incidence rates.

Peritonitis is the most important clinical complication in the PD setting, and several strategies have been used to prevent infectious complications related to PD: proper techniques for catheter insertion and exit site care (including the daily use of topical antibiotics) and a careful training of patients to enable them to safely perform PD exchanges [8]. However, despite all efforts to standardize such procedures in PD, the incidence of peritonitis continues to vary greatly between countries and even within different regions of a country [3, 9–11]. The peritonitis incidence in our study is in accordance with current recommendations from the International Society for Peritoneal Dialysis (ISPD) and show an improvement compared with historical Brazilian single-center descriptions [12, 13].

Previous single-center studies addressed the association between duration of training with clinical outcomes related to infectious complications. Some of them observed an association with reduced rates of exit site infection but with no impact on peritonitis rates. Most of these studies utilized training times ranging from 14 to 29 h [14, 15]. The only study to have found an association with peritonitis rates was a pediatric survey in which the greater the time spent on theory and practical/technical content the lower the association with peritonitis rates [16]. In another study with nurses from different countries using a questionnaire to assess number of training hours and incidence of peritonitis, no relationship was found [7]. In contrast, we found a significant reduction in peritonitis rates when >15 h of trained were offered by the center (the median of training duration in our study) and one or more hours of training were delivered by training session. This number of hours could be lower for those with >4 years of education or >65 years old. Regarding the age of patients, another study found that elderly patients required a

significantly greater length of time (5 days) when compared with the control group (4 days) [17]. Otherwise, a study aimed to evaluate the efficiency and effectiveness of PD training using a new cycler designed with animation, visual images and voice cues found no correlation between the number of hours needed for successful training and age ($r = 0.30$) [18].

An important factor commonly reminded in clinical guidelines is related to patient training. It is important to note that patient training should not be confounded with educational level of the patient. Nevertheless, literacy was also independently associated with peritonitis incidence (Table 3). It is generally well accepted that patient training should be adjusted individually according to each specific need.

The importance of pre-dialysis education can be observed in different settings. Early PD initiation planning and reducing urgent dialysis initiation seems to be beneficial. Training prior to elective transfer from HD to PD can also be organized. [19].

Following the same line, one of the major recommendations of the ISPD guidelines for patient training is to use adult learning theory [4]. In a survey among PD nurses, only 31% of respondents had a formal background in adult education [7]. The use of andragogy (adult learning) requires the identification of the type of learner, in this case patient or caretaker, and the capacity to plan the training. To achieve such goals, dialysis nurses should have some adult learning knowledge. In our cohort, we did not have any information on nurses' background experience or education. There is conflicting information regarding the experience of PD nurse in the occurrence of peritonitis. Yang *et al.* [20] showed that patients trained by nurses with advanced experience in general medicine prior to working with PD was associated with lower risk for first-episode of gram-positive peritonitis, but was not significantly correlated with all-cause peritonitis risk. In contrast, Chow *et al.* observed an interesting negative association between the length of time in practice of the trainer and peritonitis incidence [21]. Unfortunately, in the present study, data on experience of nurses in each center were not available. This may indicate that the most important factor for patient training to reduce the risk of peritonitis is the skill of the training nurse. Well-designed training and educational programs use both active and passive methods [14]. The majority of centers use didactic material from dialysis companies, emphasizing hand hygiene, technical skill, exit site care and identifying complication during training.

The key to teaching adults is to provide new information that is relevant and usable within a relatively short period of time. In our study, the length of a training session as well as the total length of training was quite variable, where <1 h of training/day was associated with higher incidence of peritonitis. It is important to make the distinction between education and learning. Education should result in changes in knowledge and skills, and the educator the agent who presents stimuli and reinforcement, while learning is the act or process by which behavioral change are acquired [22]. In this cohort, information on patients/caretaker competence at the end of training was not available, so we used peritonitis rates as a surrogate measurement to assess learning.

Regarding the timing of training, previous surveys with nurses report that in some countries such as USA, Canada and Netherlands, most centers train their patients after catheter insertion. On the other hand, in Hong Kong and South America, one-third are performed before catheter insertion. Ours results point that training either before or late after the catheter insertion, but not immediately after the procedure, was associated with better outcomes [7, 23]. This finding most likely reflects differences related to the urgent need of dialysis: if the training occurred before catheter implantation or not immediately after the procedure, this patient probably had the opportunity to choose his/her modality and have time to prepare for it. Additionally, we observed that patient training before catheter insertion and 10 days after catheter insertion presented lower incidences of peritonitis compared with those that started training immediately after catheter insertion. Simulation learning experience is recognized as the most important innovation in medical education, and by training patients before catheter implantation, we are using a simulation approach that involves learning by doing through practice, rehearsal and role playing, during which they are given the opportunity to become accustomed to therapy, technique prior to undergoing the procedure, whereas they are not very uremic and their minds are free of medications that could impair learning [24].

Center size, as a measure of center experience, is another factor that positively influences outcomes in PD [25–29]. Technique failure was described to be better during the first and second year of dialysis in centers with >25 patients [27]. Similar to a previous report, technique survival was better in larger centers [28]. In line with this assumption, we found a striking reduction in peritonitis incidence in more experienced centers. Nevertheless, a cutoff for the minimum number of PD patients to define a center with good experience is yet to be defined.

This study has some limitations. First, this is an observational study and, as such, all significant associations should be interpreted with caution. Second, we did not have detailed information regarding training methods on specific topics, such as curriculum of trainers, criteria for determining training success, time of expertise of nurses or formal education for adult teaching. Nevertheless, our study has some very important strengths, since it is the first ever attempt to analyze training patterns and clinical outcome in a prospective, nationwide, cohort with outcomes adjusted for several clinical and demographic covariates. Its characteristics share several similarities with other cohorts from different parts of the world, supporting the potential generalization of our results.

In conclusion, this is the first study to demonstrate an association between patterns of training and incidence of peritonitis. Total hours of training (regardless of the number of hours of training per day), smaller center size and the timing of training in relation to catheter implantation were associated with worse peritonitis rates. Our data support the theory that a minimum of 15 h of training should be given to all patients starting PD.

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## CONFLICT OF INTEREST STATEMENT

R.P.F. received research grants, consulting fees and speaker honorarium from Baxter Healthcare. A.F. received consulting fees and speaker honorarium from Baxter Healthcare. P.B. received consulting fees and speaker honorarium from Baxter Healthcare. T.P.M. received consulting fees and speaker honorarium from Baxter Healthcare. The other authors declare that they have no other relevant financial interests. J.B. received consulting fees and honorarium from Baxter Healthcare.

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