Despite recent advances in peritoneal dialysis (PD) systems, peritonitis is a significant clinical problem in patients on PD. Risk factors for peritonitis are identifiable and modifiable and require focused intervention. During a baseline period in 1998, we observed consistent differences in peritonitis rates among patients using various PD connection systems. In January 1999, motivated by a need to reduce peritonitis, we initiated a multifaceted continuous quality initiative (CQI) program that included retraining all current patients and all new patients 6 months after initiation and then annually; changing from plastic to titanium adapters between the catheter and the transfer set; and using equipment from a single PD manufacturer for all new patients and for current patients with high peritonitis rates. Furthermore, all patients using HomeChoice cyclers (Baxter Healthcare Corporation, McGaw Park, IL, U.S.A.) were taught to use the Compact Exchange Device II to avoid contamination when spiking solution bags.

Peritonitis rates improved from 1 episode per 7.5 patient–months (over 512 patient–months) in 1998 to 1 episode per 36.5 patient–months (over 292 patient–months) as of September 2002. Further analysis also showed a significant difference in peritonitis rates between equipment produced by various manufacturers. There was a statistically significant difference in peritonitis for automated peritoneal dialysis systems. Patients using the Freedom Cycler PD+ (Fresenius Medical Care, Frankfurt, Germany) had an average peritonitis rate of 1 episode per 6.9 patient–months as compared with patients using the HomeChoice cycler (Baxter Healthcare), who experienced 1 episode of peritonitis per 23.9 patient–months on average (p < 0.0001). For continuous ambulatory peritoneal dialysis patients using UltraBag (Baxter Healthcare), the peritonitis rate was 1 episode per 26 patient–months as compared with the Premier Double Bag (Fresenius Medical Care), for which a peritonitis rate of 1 episode per 6.3 patient–months was seen (p < 0.0001). Comparison of the UltraBag (1 episode per 26.0 patient–months) with the Disposable Freedom Set, a single-bag “Y" system (Fresenius Medical Care; 1 episode per 7.5 patient–months) yielded similar results (p < 0.0001).

We conclude that ongoing CQI efforts can significantly reduce peritonitis rates. Our efforts included aggressive patient retraining, protocol changes, use of a titanium adapter between the catheter and the transfer set, and careful choice of connectology systems (possible supplier-dependent effect).

Key words
Peritonitis, multifaceted, CQI

Introduction
Peritonitis is a major complication of peritoneal dialysis (PD) that affects both morbidity and quality of life. Hospitalization rates for peritonitis range from 13.5% to 23% of admissions among PD patients (1). Peritonitis is also the leading cause of transfer to hemodialysis (2); however, the rate of transfer can be reduced through focused, ongoing intervention. Strategies to reduce peritonitis are therefore fundamental to the management of PD patients.

One major area of improvement has been PD connection systems. Better connection systems have had a significant impact on the incidence of peritonitis and technique failure (3). Significant improvement was noted with the introduction and widespread adoption of the Y-set and twin-bag configuration for PD connection systems (4). Using a randomized controlled design, Monteon et al. (5) reported a 50% reduction in peritonitis incidence with the Y-set and a 75% re-
duction with the twin-bag configuration as compared with standard-bag systems. A systematic review (3) of 12 randomized controlled trials that compared twin-bag or Y-set exchange systems with standard systems or with each other showed significantly lower rates of peritonitis with either the Y-set or the twin-bag system than with standard systems [odds ratio (OR): 0.33; 95% confidence interval (CI): 0.24 to 0.46], and with the double-bag than with the Y-set system (OR: 0.44; CI: 0.27 to 0.71).

Two components of dialysis patient management that can have an effect on the incidence of peritonitis are selection of the dialysate delivery system and initiatives for peritonitis prevention. We report here the results of a comprehensive program aimed at reducing the peritonitis rate in our PD patient population over a 4-year period.

Patients and methods
Between September 1998 and October 2002, a multidisciplinary team at Henry Ford Hospital and Greenfield Health Systems implemented a continuous quality initiative (CQI) program to evaluate and reduce peritonitis in continuous ambulatory peritoneal dialysis (CAPD) and automated peritoneal dialysis (APD) patients alike. At the time that the initiative was undertaken, the peritonitis rate was 1 episode per 7.5 patient-months. Peritonitis was defined according to the criteria of the ad hoc Advisory Committee on Peritonitis (6) of the International Society for Peritoneal Dialysis.

We instituted a multifaceted approach to reducing the peritonitis rate. Despite initial efforts focused on retraining all patients on their current dialysis delivery systems, peritonitis rates remained unacceptably high. In 1999, all new patients were trained to use the UltraBag system (Baxter Healthcare Corporation, McGaw Park, IL, U.S.A.) or HomeChoice (Baxter Healthcare). Other CQI initiatives included changing from plastic to titanium adapters between the catheter and the transfer set; instituting patient retraining for all patients 6 and 12 months after initial training, and annually thereafter; using the Compact Exchange Device II (Baxter Healthcare) for all HomeChoice patients; and instituting a more vigorous treatment regimen for wet and dry contamination.

Patients
A total of 134 patients were included in the analysis (Table I). Average age was 52.9 years; 78 patients (58.2%) were male; 54 patients (40.3%) had diabetes; 56 patients (41.8%) were hypertensive; 90 patients (67.2%) were African-American; and 38 patients (28.4%) were Caucasian.

In 1998, 40 of the 55 prevalent patients (73%) were using CAPD and APD products from Fresenius Medical Care (Frankfurt, Germany), including the Premier Double Bag (8 patients), the Disposable Freedom Set, a single-bag “Y” system (12 patients), and the Freedom Cycler PD+ (20 patients). In the same year, 15 (27%) patients were using CAPD and APD products from Baxter Healthcare, including the UltraBag system (9 patients) and HomeChoice (6 patients). By October 2002, 1 patient remained on the Freedom Cycler PD+. All other patients used the UltraBag (29 patients) and HomeChoice systems (11 patients).

Results
The baseline peritonitis rate in September 1998 was 1 episode per 7.5 patient-months (over 512 patient-months). At the end of the evaluation period, peritonitis rates had decreased to 1 episode per 36.5 patient-months (over 292 patient-months; \(p < 0.0001\); Figure 1).

A more in-depth analysis showed a significant difference between patients using equipment from different manufacturers (Figure 2). When CAPD systems were compared, peritonitis rates were 1 episode per 6.3 patient-months with the Premier Double Bag system as compared with 1 episode per 26 patient-months with the UltraBag system \(p < 0.0001\). In a separate comparison of the UltraBag system to the single-bag Disposable Freedom Set, the peritonitis rate was 1 episode per 7.5 patient-months with the Fresenius system \(p < 0.0001\). Peritonitis rates in APD were also significantly lower with the HomeChoice systems.

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>134</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Average age (years)</td>
<td>52.9</td>
</tr>
<tr>
<td>&gt; 65 years</td>
<td>24 (17.9%)</td>
</tr>
<tr>
<td>Sex Male</td>
<td>78 (58.2%)</td>
</tr>
<tr>
<td>Race White</td>
<td>38 (28.4%)</td>
</tr>
<tr>
<td>Black</td>
<td>90 (67.2%)</td>
</tr>
<tr>
<td>Other</td>
<td>6 (4.5%)</td>
</tr>
<tr>
<td>Primary cause of ESRD</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>56 (41.8%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>54 (40.3%)</td>
</tr>
<tr>
<td>Glomerular nephritis</td>
<td>14 (10.4%)</td>
</tr>
<tr>
<td>Other</td>
<td>10 (7.5%)</td>
</tr>
</tbody>
</table>

ESRD = end-stage renal disease.
cycler (1 episode per 23.9 patient–months) than with the Freedom Cycler PD+ (1 episode per 6.9 patient–months; \( p < 0.0001 \)).

Hospitalization days attributable to peritonitis decreased significantly during the period of the CQI initiative, from 246 days in 1998 to only 23 days in the first 10 months of 2002 (Figure 3). Hospitalization days increased in 2001, but the number for that year was somewhat skewed by 1 hospitalization that lasted 38 days. The number of patients transferred to hemodialysis as a result of peritonitis also declined significantly during the CQI initiative, from 15 in 1998 to 0 in the first 10 months of 2002 (Figure 4).

Discussion
The PD team at Henry Ford Hospital and Greenfield Health Systems knew that it needed to focus on peritonitis prevention to have a significant impact on peritonitis rates. The CQI program provided a framework for improving both patient and staff PD practices, and helped to maintain focus on reducing and preventing peritonitis. Through organized interventions and outcome tracking, peritonitis prevention became integral to daily patient care. The hallmark of our approach was the switch from using both Fresenius and Baxter connectivity systems to using Baxter systems exclusively as new patients were initiated. That decision was based on the observation that the peritonitis rate appeared to be lower with the Baxter systems, which was later confirmed in the analysis. The initial number of patients was too low to determine if the difference was significant; however, during the period of the present analysis (September 1998 to October 2002), a statistically significant difference in peritonitis rate was found between the systems.

A difference in the peritonitis rates between single-bag and twin-bag systems was expected (3). The reason for the difference in the peritonitis rates of competing twin-bag systems could not be determined.

FIGURE 1 Peritonitis rates improved significantly over time (from 1 episode per 7.5 patient–months to 1 episode per 36.5 patient–months). Pt Mos. = patient–months.

FIGURE 2 Peritonitis rates differed significantly between systems. PD = peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; APD = automated peritoneal dialysis; Mo = months.

FIGURE 3 Hospitalization days attributable to peritonitis decreased. *One patient hospitalized 38 days.

FIGURE 4 Transfer of patients (Pts) to hemodialysis (HD) improved dramatically.
from this retrospective and nonrandomized evaluation. System design differences almost certainly played a role in the difference in peritonitis rates. Specifically, the design of the Fresenius transfer set for the CAPD and APD systems may have played a role in the higher peritonitis rates found with those systems. Mastering the use of those systems was certainly difficult for some patients. A significant number of Fresenius patients would forget to clamp off the transfer set before connecting and would also fail to call and report a wet contamination. Finally, previously documented differences in the Y-set design and connectivity (3–5) may be a factor in the reduction of peritonitis with the Baxter systems. The configuration of the Baxter “Y” is asymmetric, allowing contaminates to flow directly to the drain, rather to recirculate and possibly to flow back to the patient.

In addition to changing connectivity systems, we also implemented other changes in protocol. Before the CQI initiative, all patients were retrained after an episode of peritonitis. We decided to begin retraining all patients 6 months after their initial training and annually thereafter. Many patients had developed potentially serious technique problems—such as poor hand washing, forgetting to mask, and crossing over the sterile connections—that were identified ahead of possible future complications. We also retrained all patients on an annual basis, reinforcing initial training on aseptic technique and on signs and symptoms of peritonitis. The focus on prevention reinforced good technique in our patients, instead of waiting for a break in technique to signal a problem.

In a continual effort to look at other aspects of PD in our unit, the adapter from the catheter to the transfer set came under scrutiny. The original adapter was plastic and had only 19 mm of tread. The significance of the contribution from that design was unclear, but it appeared that, if the transfer set were loose and were to be retightened by the patient, contamination could occur. We elected to change all patients to a titanium locking adapter that had 38 mm of tread.

The present CQI program resulted in consistent improvement in all parameters relating to rates of peritonitis and hospitalization attributable to peritonitis. The program also resulted in significant savings in both direct cost of care and staff time. Although the number of patients transferred to hemodialysis owing to peritonitis unexpectedly increased in 2000, that increase may have been related to a documented increase in gram-negative micro-organisms. In the subsequent years (2001 and 2002), a reduction in infection rate was paralleled by a substantial improvement in our ability to maintain patients on PD.

Conclusions
Reducing the peritonitis rate reduces costs and need for hospitalization, improves ability to maintain patients on PD, and improves the patients’ quality of life. To have a sustained, significant impact on the incidence of peritonitis, the PD team focused on peritonitis prevention. Ongoing efforts and a multidisciplinary team approach significantly reduced peritonitis rates in our center. Aggressive patient retraining, protocol changes, use of titanium adapters, and careful choice of connection systems can reduce the risk and incidence of peritonitis. Ongoing attention to prevention, team involvement, and organized initiatives to improve outcomes should be implemented as a part of routine unit activity.

References

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