PD under the Universal Coverage Scheme during 2008 – 2011 (2). Since 2009, those patients have been managed at 120 PD centers (1).

Like other medical interventions, CAPD can have negative consequences, including infections and other complications (3). In 2008, during routine follow-up CAPD care, a middle-aged male ESRD patient with diabetes mellitus, hypertension, and dyslipidemia presented with some black particles in his Tenckhoff tubing and transfer set (Figure 1).

Although he had previously experienced 2 peritonitis episodes, the patient was clinically well, with no signs of peritonitis. A complete blood count, calcium and phosphate levels, liver function tests, and serum C-reactive protein and albumin were all within normal limits. However, blood urea nitrogen was 54 mg/dL, and serum creatinine was 12.54 mg/dL.

At that time, we were not aware of similar contamination in other hospitals, and we therefore decided to analyze the composition of the particles. The dialysate was centrifuged at 3000 rpm to separate the supernatant and particles. The supernatant contained no white blood cells, and no organisms were found by staining or culture. The fluid contained high levels of cancer antigen 125 (46.7 IU/mL) and protein (46.7 IU/mL). According to criteria published by the International Society for Peritoneal Dialysis (4), this patient did not have a PD-related infection. Fourier transform infrared spectroscopy revealed that the particles contained several organic compounds, such as calcium phosphate, silicone polymer, and potassium iodine (Figure 2). Histomorphologic analysis showed that the particles were composed of threadlike and fibrinous protein with reactive mesothelial cells; however, no organisms were found.

While we were conducting nationwide active surveillance of the black particles at participating hospitals, we discovered that similar contamination had been found in Banphaeo Hospital since December 2008, as noted by Chuengsaman *et al.* (5). Those authors hypothesized

Black-Stained Peritoneal Dialysis Tubing: A National Survey

Since 2008, continuous ambulatory peritoneal dialysis (CAPD) has been promoted as the main treatment for end-stage renal disease (ESRD) patients under Thailand's Universal Coverage Scheme (1,2). As a result, 3532 new peritoneal dialysis (PD) patients were initiated in 2009 (1). More than 12 000 ESRD patients were registered for

Figure 1 — Transfer set contaminated with black particles.

that iodine-based disinfectant was the cause of the contamination, and they therefore tried to keep iodine out of the abdominal cavity. However, as of February 2010, at least 159 of 430 CAPD patients had experienced black particles in that one hospital (5).

The objective of our study was to report the 1-year incidence of patients whose Tenckhoff tubing contained black particles.

METHODS

A questionnaire was sent to 106 collaborating dialysis centers to identify the incidence of black particles between 1 January and 31 December 2009. The respondents were mainly nurse practitioners and physicians in the centers. The questionnaire, developed through a discussion with care providers who had seen black

particles, contained 3 sections. The first section asked about characteristics of the dialysis centers. The second section inquired about the clinical and demographic characteristics of the patients and about the medical products and techniques used. Information that might identify the patients was excluded to ensure confidentiality. The third section asked for information about the incidence of black particles. Each incidence of black particles was subjectively graded by the respondent. It was “mild” if it could be seen only when the catheter or bag was compressed. It was “severe” if a large amount of black staining was easily noticed. Otherwise, it was “moderate.” The Student t-test and the Fisher exact test were used for data analysis, as appropriate. This study was approved by the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University (IRB no. 241/54).

Figure 2 — Fourier transform infrared spectroscopy.

RESULTS

The institutional response rate was 74.53% (79 of 106 centers). Of 79 centers with 1633 CAPD patients, 18 centers reported 94 incidents of black particles in dialysis tubing, which amounts to an annual incidence of 57.56 per 1000 CAPD cases. Table 1 shows that the general characteristics of the incident and non-incident hospitals were comparable. The average age of patients was 48.71 years (range: 12 – 81 years). Almost two thirds of the patients were men (60.67%), and almost half (46.30%) had underlying diabetes. The length of time the patients had been on PD ranged from 1 month to 11 years.

TABLE 1
Characteristics of Incident and Non-Incident Hospitals

Characteristic	Respondents (n)	Cases of black particles		p Value ^a
		Yes	No	
Beds	65	494.35 (341.35, 647.35)	476.42 (406.69, 546.14)	0.8047
Occupancy	30	90.11 (76.65, 103.58)	87.94 (83.05, 92.84)	0.6795
Doctors				
All	28	135.13 (6.01, 264.24)	125.80 (46.73, 204.87)	0.8937
Caring for PD patients	23	117.25 (–15.75, 250.25)	75.47 (34.58, 116.35)	0.3948
Region (n hospitals)				0.7940
North	7	5	2	
Northeast	19	11	8	
South	10	8	2	
West	4	3	1	
Central	12	9	3	
East	8	7	1	
Bangkok metropolitan	6	5	1	

PD = peritoneal dialysis.

^a By Student t-test or Fisher exact test.

Most of the 94 patients (79.31%) used dialysate produced by Baxter (India) Private Ltd. and Baxter Healthcare (Asia) Pte., Ltd. (20 and 49 patients respectively); 17 patients (19.54%) used products from Fresenius Medical Care (Thailand) Ltd.; and 1 patient (1.15%) used dialysate from General Hospital Products Public Co., Ltd. In 58 of 87 patients, the abdomen was allowed to dry. Almost all the patients used only povidone iodine as their antiseptic. In about one third of the patients, the catheter was soaked in antiseptic before the transfer set was changed.

Half the contamination was found in the Tenckhoff tubing only. Most incidents of black particles continued for at least 6 months. Of 32 incident patients whose grading data were available, 29 (90.63%) experienced at least a moderate number of black particles.

Almost two thirds of the incident patients were men, whose average age was 49 years. Almost half had diabetes and a history of at least 1 peritonitis episode. According to effluent cell count criteria, 7 patients whose catheter and transfer set were contaminated with black particles were found to have peritonitis. Table 2 shows that the peritonitis incidence was associated with the manufacturer of dialysate, the history of peritonitis, and the location of the contamination (Table 2). Because of missing data, we could not conclude that peritonitis was associated with a dry abdomen or with a catheter soaked in antiseptic.

DISCUSSION

Black particles are a common contaminant in our CAPD patients. Although one institution recently reported 159

prevalent cases in 430 CAPD patients (5), our national survey suggests an annual incidence of 57.56 cases per 1000 CAPD patients. That incidence is high compared with an annual peritonitis incidence of 29 cases per 1000 CAPD patients reported earlier (6).

Although the chemical and biologic properties were successfully assessed, an actual causal pathway that might be managed with preventive measures is still unclear. One explanation is catheter biofilm (7), which was noted in the study by Chuengsamran *et al.* (5); however, the composition of the contamination they reported does not support a bacterial growth theory. The association of biofilm with peritonitis is therefore questionable, despite an unpublished case-control analysis by Chuengsamran and colleagues. They decided to focus only on iodine-containing instruments and disinfectant and tried, but failed, to prevent the contamination (5).

Our study confirms that determining the cause of this contamination is crucial for the management of this complication. If the black particles are believed to be associated with a PD-related infection, empiric antibiotics should be initiated without delay (4). The Tenckhoff catheter must be removed if the black particles are believed to be biofilm (7). Most culture-negative peritonitis is explained by preceding antibiotic therapy or technical problems, and early removal of the Tenckhoff catheter is recommended (8). The conflicting diagnoses and management approaches used in the Chuengsamran *et al.* study (5) might explain the unsatisfactory outcomes, and further etiologic analysis is needed.

A few limitations should be noted. Because only patients undergoing home-based CAPD were included

TABLE 2
Factors Potentially Associated with Peritonitis

Factor	Respondents (n)	Peritonitis cases	p Value ^a
Dialysate producer			<0.001
Baxter Healthcare (Asia)	46	0	
Baxter (India) Private	9	5	
Fresenius Medical Care (Thailand)	4	2	
General Hospital Products Public	1	0	
History of peritonitis	28	22	0.034
Location of black particles			0.006
Tenckhoff tube	28	6	
Transfer set	3	1	
Tenckhoff tube and transfer set	29	0	
Patient had a period with dry abdomen	37	6	0.233
Catheter soaked in antiseptic	3	2	1.000

^a By Fisher exact test.

in our study, the incidence reported here is likely to be underestimated. However, because most of the CAPD patients in Thailand are home-based, that underestimation is probably minimal.

ACKNOWLEDGMENTS

We thank the patients and nurses from all the participating dialysis centers. This project received partial support from the Ratchadapiseksompotch Fund, Faculty of Medicine, Chulalongkorn University, grant no. GDNS 55-077-30-009.

The results presented in this paper have not been published previously in whole or part, except in an abstract accepted for oral presentation at the 28th Annual Conference of the Royal College of Physicians of Thailand, in April 2012, and in a poster presentation at the 14th Congress of the International Society for Peritoneal Dialysis, 9 – 12 September 2012, in Kuala Lumpur, Malaysia.

DISCLOSURES

The authors have no financial conflicts of interest to declare.

Wannarat Amornnimit¹

Krit Pongpirul^{2,3*}

Pichet Sampatanukul⁴

Kriang Tungsanga¹

Piyaratana Tosukhowong⁵

Talerngsak Kanjanabuch¹

Department of Internal Medicine¹

Department of Preventive and Social Medicine²

Faculty of Medicine

Chulalongkorn University

Bangkok, Thailand

Department of International Health³

Johns Hopkins Bloomberg School of Public Health

Baltimore, Maryland, USA
Department of Pathology⁴
Department of Biochemistry⁵
Faculty of Medicine
Chulalongkorn University
Bangkok, Thailand

*email: doctorkrit@gmail.com

REFERENCES

1. Praditpornsilpa K. Thailand renal replacement therapy year 2009. In: Praditpornsilpa K, ed. *Thailand Renal Replacement Therapy Year 2009*. Bangkok, Thailand: Medical Publisher; 2010.
2. Dhanakijcharoen P, Sirivongs D, Aruyapitipan S, Chuengsaman P, Lumpaopong A. The “PD First” policy in Thailand: three-years experiences (2008–2011). *J Med Assoc Thai* 2011; 94(Suppl 4):S153–61.
3. Saxena R, West C. Peritoneal dialysis: a primary care perspective. *J Am Board Fam Med* 2006; 19:380–9.
4. Li PK, Szeto CC, Piraino B, Bernardini J, Figueiredo AE, Gupta A, et al. on behalf of the International Society for Peritoneal Dialysis. Peritoneal dialysis-related infections recommendations: 2010 update. *Perit Dial Int* 2010; 30:393–423. [Erratum in: *Perit Dial Int* 2011; 31:512]
5. Chuengsaman P, Panomrerngsak A, Sriudom K, Srisirichokchai A, Srisangawong V. Black particles: first report in peritoneal dialysis (PD) patients (Abstract). *Perit Dial Int* 2010; 30:S18.
6. Sirivongs D, Pongskul C, Keobounma T, Chunlertrith D, Sritaso K, Johns J. Risk factors of first peritonitis episode in Thai CAPD patients. *J Med Assoc Thai* 2006; 89(Suppl 2):S138–45.
7. Dasgupta MK, Larabie M. Biofilms in peritoneal dialysis. *Perit Dial Int* 2001; 21(Suppl 3):S213–17.
8. Szeto CC, Wong TY, Chow KM, Leung CB, Li PK. The clinical course of culture-negative peritonitis complicating peritoneal dialysis. *Am J Kidney Dis* 2003; 42:567–74.
doi:10.3747/pdi.2012.00167