A Preliminary Report on the Effectiveness of Nanotechnology Anti-Microbial Spray Dressing in Preventing Tenckhoff Catheter Exit-Site Infection

For most patients receiving peritoneal dialysis (PD), there is evidence showing that their satisfaction and quality of life have been increasing (1). However, the Tenckhoff catheter (TC) can become a potential source of infection and peritonitis. If exit-site infection (ESI) is not well managed it can lead to peritonitis or require removal of the TC (2). Peritonitis is a well-known cause of mortality in PD patients (3). Consequently, suspending treatment due to access failure may affect patients' overall health status. The purpose of routine care of the exit site is to prevent ESI. There is a large volume of information focused on the prevention of ESI, with different approaches being proposed. The practice guidelines and protocols from institutions are varied and have not been adequately evaluated, although large volumes of data have been published on the prevention of ESI (4).

Several recent trial studies show that the application of JUC Physical Antimicrobial Spray Dressing (NMS Technologies Company Limited, Nanjing, Jiangsu Province, China), has proven to be effective in the prevention of lower urinary tract infection where the spray was applied on the surface of the catheter and the urethral orifice (5,6), treatment of post-operative infection for oral cancer (7), open wound treatment in emergency clinics (8), and managing radiation-induced acute skin reactions (9). It is also an alternative to antibiotic treatment on wound management for patients with methicillin-resistant *Staphylococcus aureus* (MRSA) infection (10). JUC spray dressing was developed in China in 2002 and registered as a dressing product by the United States Food and Drug Administration in 2006. The spray consists of 2% organosilicon quaternary ammonium salt and 98% distilled water, and is safe for application, even for contact with eyes and mucous membranes. It is composed using nano-manufacture technology, yet the antibacterial mechanism is not fully understood. Some proposed mechanisms relate to the physical structure of the nanoparticles while others relate to the enhanced release of antibacterial metal ions from nanoparticle surfaces which interact with and penetrate into the bacteria (11).

Proper exit-site care is of paramount importance in reducing TC-associated infection and subsequent catheter loss. In current practice, patients who have a TC are usually advised to use the traditional antiseptic 0.05% chlorhexidine in exit-site care. Previous studies suggest that 0.05% chlorhexidine is able to reduce the bacterial load in the wound and promotes cell growth (12). In this study, JUC spray was applied to the TC exit site to compare the incidence of ESI with the usual standard care. In addition to ESI, the existence of skin allergy, catheter damage, and time spent on exit-site dressing were examined.

METHODS

The study was carried out through a randomized controlled trial. Patients were recruited from the renal unit of a 1,700-bed acute-care, general regional hospital in Hong Kong. Those patients who did not receive oral or external antibiotics and who had a TC in place for at least 3 months were recruited sequentially. Patients presenting with signs and symptoms of exit-site infection and poor healing of exit site were excluded. There were 121 patients assessed for eligibility and 47 subjects were excluded. The reasons for exclusion were patients not meeting the inclusion criteria or refusing to participate. To compute the sample size, we referred to Li *et al.* (10) on the effectiveness of JUC spray to prevent ventilator-associated pneumonia. To have 80% power, $\alpha = 0.05$, to detect a 27.9% reduction in the incidence of bacterial colonization in the pharyngeal cavity in the experimental group compared with the control group, a sample size of 35 subjects for each group was required. The catheter was inserted surgically by open surgical incision. It was well secured with a dressing and PD was started 4 weeks

after insertion. A 47-cm Argyle Peritoneal curl catheter with double cuff (Covidien, Mansfield, MA, 02048 USA) was used for both groups of patients.

A total of 78 patients were randomized into study or comparison group by the researcher using computer-generated numbers. Baseline data were collected before randomization with masking of treatment allocation. It was a single-blinded study as the patients were not blinded to the group assignment while the data collector was blinded to group allocation. The study group patients used JUC spray dressing while the comparison group used 0.05% chlorhexidine dressing daily for standard wound care. Coaching was provided by the nurses to ensure that the patients were able to perform the procedures correctly. The study team called the patients on the first 3 days and they were instructed to report any abnormalities they noticed to the nurses, such as signs and symptoms of infection, skin allergy, and TC damage. The patients were treated with a full course of antibiotics prescribed by the physician if diagnosed for ESI and they continued with the study after full recovery from treatment. Clinical efficacy was assessed for a period of 6 months after implementation of intervention.

According to the study unit protocol, the presence of 2 out of 3 equivocal signs and symptoms of ESI was diagnosed as acute ESI. Signs and symptoms included red color around the exit site, with 3 – 4 mm measurement from the edge or purulent discharge.

RESULTS

A total of 74 patients, 37 each in the study and comparison groups, were included in the final analysis. Continuous variables are expressed as median (range) and were analyzed using Mann-Whitney U-test. Categorical variables were analyzed using Chi-square test or Fisher's Exact test. The demographic and clinical information was examined and no significant difference was found between the 2 groups except age. See Table 1 for details.

Exit-site infection developed in 2 patients (5.4%) in the study group and 9 patients (24.3%) in the comparison group. The results were significant ($p = 0.02$) for the 2 groups. Among the 9 patients in the comparison group, ESI occurred twice during the 6-month period in 2 patients. The 2 patients who developed ESI in the study group were 45 and 65 years of age, ages of individual patients in the comparison group were: 50, 1; 58, 2; 61, 1; 73, 1; 75, 1; 80, 2; and 82, 1. There was 1 patient in the comparison group who reported damage to the catheter, having a small crack near the distal part of the TC as confirmed by the physician of the study unit. No allergic

TABLE 1
Demographic Data and Clinical Characteristics of the Study Population (n=74)

	Study Group (n=37)	Comparison Group (n=37)	p-value
Age[a]	56 (47.5–74)	72 (60–75.5)	0.01[c]
Duration of TC insertion (month)[a]	25 (11–46)	17 (10.5–54.3)	0.94
Gender[b]			0.34
Male	18 (48.6%)	14 (37.8%)	
Female	19 (51.4%)	23 (62.2%)	
Diabetes[b]			0.32
Yes	10 (27%)	14 (37.8%)	
No	27 (73%)	23 (62.2%)	
Normal albumin[b]			0.10
Yes	14 (37.8%)	21 (56.8%)	
No	23 (62.2%)	16 (43.2%)	
Previous ESI[b]			0.81
Yes	16 (43.2%)	15 (40.5%)	
No	21 (56.8%)	22 (59.5%)	

TC = Tenckhoff catheter; ESI = exit-site infection.
[a] Continuous variables are expressed as median (25^{th}–75^{th} percentile).
[b] Categorical variables are expressed as count (column %).
[c] $p<0.05$.

TABLE 2
Results at Six Months Post-Intervention

	Study Group (n=37)	Comparison Group (n=37)	p-value
Allergy[a]			—
No	37 (100%)	37 (100%)	
Exit site infection[a]			0.02[c]
Yes	2 (5.4%)	9 (24.3%)	
No	35 (94.6%)	30 (75.7%)	
TC damage[a]			1
Yes	0 (0%)	1 (2.7%)	
No	37 (100%)	36 (100%)	
Time used for dressing (minutes)[b]	2 (1–8)	10 (2–15)	<0.001[c]
Treatment cost (HK$)	0.50	3.00	

TC = Tenckhoff catheter; HK$ = Hong Kong dollars.
[a] Categorical variables are expressed as count (column %).
[b] Continuous variables are expressed as median (range).
[c] p<0.05.

reactions were reported for either group of patients. Time spent on TC dressing was significantly shorter in the study group (median: 2 minutes) than in the comparison group (median: 10 minutes). The study group patients were all satisfied with the new treatment. The cost for chlorhexidine dressing was HK$3.00 (equivalent to US$0.38) per dressing, while the cost for JUC spray was HK$0.50 per application. See Table 2 for results.

Eleven samples were taken for bacteria analysis from the infected exit sites of both groups and the results confirmed bacteria growth. Coagulase-negative *Staphylococci*, *Diphtheroid bacillus*, *Pseudomonas aeruginosa* and *Streptococcus salivarius* were found mostly in the wounds of the comparison group. *Acinetobacter* spp and *Pseudomonas* spp were found in the JUC group.

DISCUSSION

Proper exit-site care is of paramount importance to reducing TC-associated infection and subsequent catheter loss. Adequate immobilization of the catheter and daily exit-site care are the significant issues to be investigated. Our study demonstrated that JUC spray can replace traditional disinfectants for exit-site care as it does not cause adverse effects and can counter the problem of drug resistance. The results demonstrated that the incidence of ESI in the treatment group was significantly lower than in the comparison group. Although it is difficult to draw definite conclusions about the relative efficacy given the much younger average age of the treatment group, the data suggest that the JUC spray is at least as effective as standard chlorhexidine protocol.

JUC physical antimicrobial dressing is considered a new method for safely and effectively preventing the onset of ESI. In the application of JUC, the easy-to-use treatment also reduced the time spent on daily TC exit-site care. The procedure is convenient and facilitates wound inspection. Once JUC is sprayed on the skin surface, it dries within 30 seconds, thus reducing the time, effort, and discomfort of exit-site care. It is actually invisible and does not cause uncomfortable feelings to the patients or cause damage to the PD catheter. Patients enjoy better quality of life, as daily exit-site care is no longer a burden. However, our results on time savings need to be interpreted with caution as patients in the study group were significantly younger; and the younger patients may perform faster in daily activities than older patients, depending on the nature and severity of their respective conditions. Antibiotic resistance may be the result of extensive use of antibiotics for end-stage renal failure patients with compromised immune systems. The use of JUC spray can play a role in exit-site management for patients who may be sensitive to chlorhexidine and/or antibacterial agents. Medical expenses in public hospitals in Hong Kong are heavily subsidized by the Hong Kong government. The use of JUC spray to replace traditional dressing materials and methods could reduce the financial burden on Hong Kong's healthcare system by reducing medication expenses.

CONCLUSION

JUC spray is a simple, safe and sustainable technique for TC care. Further studies are required using a larger sample size to investigate the applicability of JUC in exit-site care for patients from multiple age categories residing in hospital renal units and in the community.

DISCLOSURES

The authors have no financial conflicts of interest to declare.

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