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A Survey on Bacterial Contamination of Lavage Water in Electric Warm-Water Lavage Toilet Seats and of the Gluteal Cleft after Lavage

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Abstract : Electric warm-water lavage toilet seats are in wide use as an appliance beneficial for the maintenance of hygiene and the prophylaxis and improvement of conditions such as constipation and hemorrhoids. In this study, we surveyed the bacterial content in the lavage water of warm-water lavage toilet seats, and fecal bacterial contamination of the gluteal and genital regions due to droplet infection from post-defecation lavage, to examine the problems inherent to the use of such lavage units. The presence of viable bacteria in lavage water was confirmed in this survey. Viable bacterial counts in lavage water were 3-times higher in household units compared to units in public facilities, suggesting a correlation with the replenishment of lavage tank water with fresh water containing residual free chlorine.

Keywords : warm-water lavage toilet seats, toilets, bacterial contamination.

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Introduction

Warm-water lavage toilet seats are toilet seats with lavage functions for cleaning the anal and genital regions. According to a consumer trend survey by the Japanese Cabinet Office, the prevalence of warm-water lavage toilet seats reached as high as 70.9% as of March, 2011[1]. The Japanese are both a highly hygiene-conscious people and a race plagued by conditions such as constipation and hemorrhoids. Upon this background, lavage using electric warm-water toilet seat units has gained wide use as an appliance for maintaining cleanliness of the perianal region after defecation, and for prevention or improvement of constipation and hemorrhoids by stimulating the rectal

region with warm water to promote anodermal blood circulation [2]. Furthermore, the potential of warm-water toilet-seat-type lavage units for maintaining hygiene in elderly nursing home residents has been reported in the United States [3]. However, there has yet to be a detailed analysis of bacterial contamination of lavage water, or adherence of fecal bacteria in the gluteal and genital regions due to spattering by lavage water in post-defecation use. we surveyed bacterial contamination of the lavage water and adherence of fecal bacteria in the gluteal and genital regions to examine the problems inherent in the use of toilet-seat warm-water lavage units.

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Materials and Methods

Contamination of lavage tank water and chlorine concentrations: 1. Water sampling sites: 1) Bacterial contamination of lavage water; Lavage unit water was collected from tank-type warm-water lavage toilet seats in 85 common households (Company A : rate of Lavage Water 1.3 l/min) and 28 public facilities (Company B : rate of Lavage Water 0.90 l/min) in Kanagawa Prefecture. 2) Lavage tank-water bacterial contamination in the early morning/afternoon; Lavage unit water was collected in the early morning (6~10 a.m.) and afternoon (2~4 p.m.) from tank-type warm-water lavage toilet seats in 6 common households and 4 public facilities in Kanagawa Prefecture. 3) Free chlorine concentrations in toilet-seat lavage tanks Lavage water were collected as described in 2) above, once a day over 5 days.

Collection of water samples: The lavage nozzle was wiped with ethanol cotton (Orion Yakuhin Kogyo, Co. Ltd.), air-dried, and water was run for 5 seconds to allow for drainage of water within the nozzle itself before collection into 50 ml sterile centrifuge tubes (Iwaki, Co. Ltd.).

Culture media: Heart infusion (HI) agar was used for estimating total counts of bacteria, *P. aeruginosa* was isolated in nalidixic acid cetrime (NAC) agar, and *E. coli* was isolated using deoxycholate-hydrogen sulfide-lactose (DHL) agar (all from Nissui Pharmaceutical, Co. Ltd.).

Enumeration of bacteria and identification: Lavage unit water samples were smeared on agar media (HI, NAC, DHL) and incubated aerobically at 37°C for 48 hours, followed by enumeration of colony forming units (CFU).

Evaluation of free chlorine concentration in lavage unit tank water: The collected samples were immediately tested for residual free chlorine by the N,N-diethyl phenylene-diamine (DPD) method.

Bacterial contamination of gluteal and genital regions following defecation and cleansing using toilet-seat lavage units: 1) Sampling areas; Sixty-two samples were collected from the gluteal region and 16 from the genital region of one male subject, in the early morning between July and September, 2008. 2) Culture media; X-Gluc, Magenta-Gal (XM-G) agar food stamp media for *E. coli* and coliform bacteria

(Nissui Pharmaceutical, Co., Ltd.) were used. 3) Sampling areas and methods; Gluteal region samples were collected approximately 5 cm to the left and right of the anus. Genital samples were collected approximately 10 cm forward from the anus. Samples of the gluteal and genital region were collected by pressing the food stamps against the sampling area for 5 seconds. Control samples were collected by stamping prior to defecation, after wiping the testing area with ethanol cotton (Sanicott, Orion Yakuhin Kogyo, Co. Ltd.), and air drying to remove any direct effects of alcohol. Testing samples were collected after defecation and warm-water lavage. 4) Enumeration of bacteria; Counts of bacteria adherent to the gluteal and genital regions were enumerated (CFU) following aerobic incubation of the food stamps for 24~48 hours.

Statistical analysis: Data were subjected to Welch's *t*-test using SPSS software (Ver. 17).

The study was conducted with approval by the Ethics Committee of Venex Co. Ltd.

Results

Bacterial contamination of lavage unit water: Figure 1 gives the mean total bacterial counts from lavage tank water samples taken from 85 households and 28 public facilities. The mean total count from the households was 293 ± 309.1 CFU, while that from the public facilities was 109.5 ± 62.9 , showing significantly high lavage tank water bacterial counts in the common household compared to that in the public facilities ($P < 0.001$). Moreover, *P. aeruginosa* and *E. coli* were isolated from the lavage tank water of a number of households.

Evaluation of free chlorine concentrations of lavage unit tank water: Early morning tank water chlorine concentrations in both the household and public facility samplings were below determinable limits. Afternoon free chlorine concentrations were > 0.1 mg/l in both household and public facility bidet tank water.

Lavage water bacterial contamination in the early morning and early afternoon: Lavage tank water was collected twice – early morning and early afternoon – from households ($n = 85$) and public facilities ($n = 28$) and tested for bacterial contamination. The mean bacterial counts from the household samples were sig-

nificantly different at 798.7 ± 504.6 (CFU $\pm$ S.D.) in the early morning, and 30.8 ± 40.7 in the afternoon samples ($P < 0.001$). On the other hand, public facility samples yielded mean counts of 57.5 ± 56.9 from early morning, and 7.3 ± 13.2 from afternoon samples – lower again in the afternoon, although the difference was not significant (Fig. 2).

Bacterial contamination of the gluteal and genital regions following lavage unit use: Table 1 shows the *E. coli* and coliform bacteria counts obtained from the

gluteal and genital regions after defecation and cleansing using the lavage unit.

Free chlorine concentration in lavage tank water: Residual free chlorine regulated by the Waterworks Law to > 0.1 mg/l upon distribution was not determinable in lavage tank water from both the household and public facility early morning samples. Afternoon samples from the public facility showed 0.3 mg/l, and between 0.1 mg/l~N.D. in the household lavage tanks.

Fig. 1. Number of bacteria in lavage unit tank water.

CFU: colony forming units

Fig. 2. Number of bacteria in early morning/afternoon samples of lavage unit tank water. —: Common households (n=6), ----: Public facilities (n=4)

CFU: colony forming units

Table 1. Adherence of *E.coli* and coliform bacteria on the gluteal and genital regions

Before or after lavage	Gluteal region (n = 62)	Genital region (n = 16)
Before	ND	ND
After	$475.2 \pm 267.5^*$ CFU	$15.8 \pm 9.8^*$ CFU

ND: Not detected, *: Mean $\pm$ SD, CFU: colony forming units

Discussion

The findings from this survey revealed bacterial contamination of water in the lavage-tank units of warm-water lavage toilet seats. Moreover, the presence of *P. aeruginosa* and *E. coli* – causative agents of opportunistic infections and cystitis – was confirmed in lavage-tank water in a number of common households. The contaminations were believed to arise from: 1) droplets of loose stools, 2) spattering of contaminated water from the toilet bowl caused by descending feces, and 3) fecal droplets from lavage use after defecation adhering to the nozzle heads, the contaminants then traveling to infiltrate and proliferate within the lavage tank.

The warm-water lavage toilet seats studied in this survey were equipped with lavage unit tanks supplied with tap water. The Waterworks Law in Japan requires a free residual chlorine concentration above 0.1 mg/l in home tap water at faucet level for purposes of sterilization and disinfection [4]. However, we were unable to detect residual free chlorine from lavage tank water. This was considered to be the result of evaporation of the chlorine due to heating and long hours of retention within the lavage tank. From this, it was inferred that bacterial proliferation was enabled within the lavage tank devoid of the disinfecting effects of chlorine.

Comparison of bacterial counts of lavage unit water in household and public facility toilet units revealed a 3-fold higher count in household lavage tank water. This was believed to result from higher concentrations of residual chlorine in public facility lavage units due to constant replenishment of fresh water containing residual chlorine from actual lavage unit use and from the automatic nozzle rinse function accompanying each instance of toilet use.

To date, use of the lavage units in warm-water lavage toilet seats has been regarded as an aid in the maintenance of hygiene following excretion, and for alleviating perianal bleeding, swelling, or pain. More-

over, there have been reports of lavage unit use being beneficial as improvement of problems with anodermal circulation associated with internal hemorrhoids, anal fissures, and for facilitating recovery from surgical trauma [3].

Our survey demonstrated adherence of fecal *E. coli* and coliform bacteria on the gluteal and genital surfaces following post-defecation lavage unit use, and spread in the area of contact contamination through toilet-paper use on droplet-infected surfaces.

This survey has demonstrated the danger of bringing about bacterial contamination in the gluteal and genital regions and facilitating the spread of infection following post-defecation use of warm-water lavage toilet seats, which has heretofore been recommended as a sanitary fixture conducive to better hygiene in medical and nursing settings. The findings also indicate the need for prophylactic measures such as glove use against the spread of contact infections from patients using lavage units and from staff caring for such patients.

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温水洗浄便座の局部洗浄水および洗浄後臀部における細菌汚染調査

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要 旨：温水洗浄便座は、排便時における清潔維持、便秘や痔の予防・改善に役立つ器具として広く使用されている。我々は、温水洗浄便座局部洗浄水中の細菌、排便後の局部洗浄水の飛沫によって引き起こされる臀部・股間に付着する糞便細菌について調査し、温水洗浄便座の使用に潜む問題について検討した。本研究結果により、温水洗浄便座局部洗浄水中の細菌生息が確認され、さらに一般家庭の局部洗浄水中生菌数は公共施設のものに比して約3倍多いことが明らかとなった。これは、補水が少頻度の一般家庭においては残留遊離塩素が揮発したためと考えられた。一方、排便後の局部洗浄より、臀部・股間における糞便細菌の付着が確認され、洗浄後に臀部において糞便細菌の飛沫付着が確認されたことから、医療従事者は、局部洗浄水利用者との接触感染に注意が求められる。

キーワード：温水洗浄便座, トイレ, 細菌汚染.

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