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# Application study on aerosol-reducing hygienic siphons for control of a 4MRGN Pseudomonas aeruginosa outbreak on a neurological early stage rehabilitation ward

## Summary

**Background:** We experienced an outbreak of 4MRGN *Pseudomonas aeruginosa (P. aeruginosa*) on a phase B neurological rehabilitation ward. This multiphase outbreak had lasted several years and was sustained because of bacterial contamination from the waste water system. This is a concise report, highlighting the clinical findings from our comprehensive microbiological investigations conducted following the installation of the HygieneSiphon drain trap made by Aqua free GmbH.

**Methods and Results:** All the patient basins on the ward had been barred from use. In November 2015 the action taken was to replace the horizontal corner waste pipes with conventional washbasins S-bend pipes and short variants of the HygieneSiphon trap were installed. To assess the new installation performance a clinical study was conducted in collaboration with the public health authority. It involved microbiological smears and direct contact tests of the traps, washbasins and aerators for 4 weeks following the installation of the HygieneSiphon traps. After 3 months the HygieneSiphon inserts were exchanged as specified by the manufacturer and these were also microbiologically tested. The microbiological investigation of the original installation (without the HygieneSiphon) showed that contamination of the washbasin occured from the original waste system after filling of the basin. Subsequent testing, once the HygieneSiphon had been installed and the pipework modifications made, showed no recurring contamination. However, after the service life of 3 months the HygieneSiphon inserts themselves became contaminated with pathogens brought in from the outside environment.

**Conclusion:** This study concludes that contamination of the washbasin and surrounding area with pathogens from the waste system can be prevented by the installation of the HygieneSiphon system. Therefore, in the event of an existing colonisation of the waste system with 4MRGN *P. aeruginosa* or other hygienically significant pathogens, we see the fitting of the HygieneSiphon as a cost effective, non-invasive method of preventing pathogenic contamination of the washbasin and surrounding area. Based on the results of this study, we believe that the HygieneSiphon can make an important contribution to reducing nosocomial colonisations/infections from sanitary installations.

**Keywords:** 4MRGN · *Pseudomonas aeruginosa* · waste water system · outbreak management · hygienic siphon

## Introduction

During investigations carried out between February 2013 and July 2015 into an outbreak of a 4MRGN *Pseudomonas aeruginosa* isolate (type 00735) with VIM-2 metallo-beta lactamase on a phase B neurological rehabilitation ward with 24 beds the only likely source identified was the washbasin drain traps (siphons) [1]. The outbreak was thought to have been caused by retrograde contamination of the washbasin or patients, in particular, when filling the washbasin for wash training exercises.

That the washbasins were barred from use as from October 2014 meant a considerable setback to the integrative rehabilitation of the patients and despite partial sanitization of the waste water system it was not possible to use these washbasins. One option contemplated for release of the washbasins was the installation of HygieneSiphons (hygienic siphons) made by the firm Aqua free GmbH [2].

HygieneSiphons are disposable devices that are inserted into the washbasin drain trap. They prevent retrograde contamination of the washbasin through the reflux of microorganisms from the drain trap. The findings of studies conducted hitherto by the firm Aqua free GmbH into the effectiveness of the HygieneSiphons had been based exclusively on in vitro testing of their capacity to retain bioaerosols from the drain trap formed above the seal water [3]. Nor were any study findings available so far on the clinical impact of installation of HygieneSiphons.

This paper now presents the results of microbiology testing of washbasins with and without installation of HygieneSiphons while simulating wash training exercises in rehabilitation clinics and with special focus on 4MRGN *P. aeruginosa*; it also reports on epidemiological investigations carried out in routine ward settings over a six-month observation period.


Figure 1: A: L-shaped siphon trap and B: Flat washbasin of rehabilitation ward.

Figure 2: S-shaped siphon trap.

## Methods

### Basic data

The washbasins concerned are flat washbasins specially designed for rehabilitation purposes with wheelchair-friendly, L-shaped corner waste pipes to facilitate patient exercises during wash training (see Fig. 1a and b).

Sanitization of the washbasin waste pipes (replacement of the drain trap [(siphon] at six-weekly intervals) prior to the study did not prove successful, i.e. drain trap recolonization was confirmed once again a few weeks after its exchange.

### Washbasin modification measures

Since it was suspected that L-bend pipes compared with the conventional S-bend pipes were more likely to permit retrograde reflux, in November 2015 the L-corner pipes of all washbasins on the implicated ward were replaced with traditional S-pipes (see Fig. 2). Regardless of the latter, this was a technical requirement for installation of the HygieneSiphons.

### Installation of the HygieneSiphons

Thanks to their design, the HygieneSiphons marketed by the firm Aqua free GmbH prevent aerosol reflux from the drain trap (see Fig. 3a and Fig. 3b).

They can be quickly fitted in the drain trap without any technical difficulty and the cost of each hygienic siphon is in the


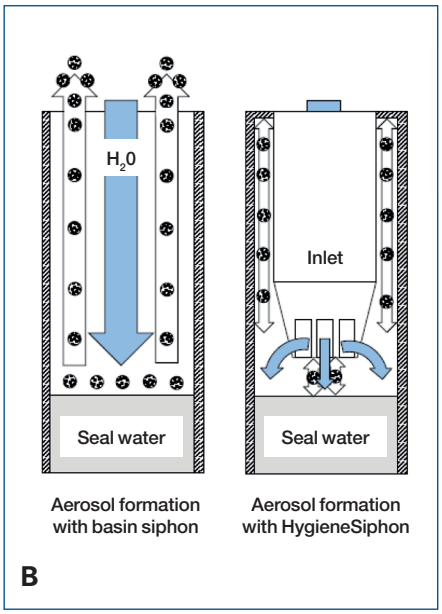


Figure 3: A: HygieneSiphon – Inlet and permanent drain valve I. B: Function of HygieneSiphon compared with that of standard siphon [7]. (Figures with kind permission of the firm Aqua free).

lower two-digit euro range. They should be replaced at three-monthly intervals as recommended by the firm Aqua free GmbH.

For functional testing initially only three of the entire 16 washbasin drain traps on the ward were fitted with HygieneSiphons (Table 1, washbasins A–C). The drain traps selected were those found to have been colonized with the outbreak strain at the time of the most recent microbiology investigation before replacement of the L-corner pipes (July 2015) and known to have exhibited intermittent colonization with 4MRGN *P. aeruginosa* during the previous two years.

### Microbiology monitoring of the drain traps and HygieneSiphons

Before microbiology testing the washbasins and fittings were disinfected with a surface disinfectant while observing the specified exposure time.

Microbiology swabs were taken from the drain traps by removing the thread for the purpose of obtaining a swab from a deep level of the trap. The water temperature while simulating the washing process was around 28–34 °C.

All microbiology samples were processed in an accredited microbiology laboratory.

1. The first microbiology tests of all 16 drain traps on the implicated ward were conducted immediately before installation of the HygieneSiphons, one week after replacement of the L-corner pipes.
2. The three patient washbasins fitted with HygieneSiphons (washbasins A–C) were microbiologically monitored over a period of four weeks (November to December 2015). Contact plate samples were taken for microbiology testing of the washbasins (close to the drain, washbasin rim at the front and rear), and swabs were obtained from the aerators (see Fig. 4), in each case on day 1, 7, 14, 21 and 28 after insertion of the HygieneSiphons. All tests were carried out with an empty washbasin, after filling the basin with water and after allowing the water to drain (simulation of wash training exercises).
3. At the end of the four-week test phase outlined under Item 2 for washbasins A–C, the HygieneSiphons were installed in the washbasins of all patient rooms and the washbasins were released again for unrestricted patient use. At the end of the three-month service life, while simulating the washing process (filling and emptying of the basin), tests were performed using a contact plating technique close to the washbasin drain as well as by swabbing the inside of the HygieneSiphon (surface inclined towards the washbasin). Next, the HygieneSiphons were removed and replaced.
4. Throughout the entire test period all patients on the ward were routinely screened on admission for 4MRGN. Furthermore, weekly screening for 4MRGN *P. aeruginosa* of all inpatients was conducted on the basis of rectal swabbing and urine examination, with this changed to two-weekly MRGN screening from January 2016.

## Results

### Before installation of the HygieneSiphons after replacement of the L-pipes

Already partial sanitization of the waste water system (replacement of L-pipes with S-pipes) reduced the isolation rate of 4MRGN *P. aeruginosa* in two of the three selected washbasins (see Table 1, 14.11.15 versus 31.7.15).

As a result of that, under study conditions one washbasin (washbasin C) was assigned to the positive group and the other two to the control group (washbasin A and B).

**Table 1: Illustration of the microbiology test results for the washbasins and aerator, with breakdown showing isolation of the 4MRGN outbreak strain in the drain traps/siphons of patient rooms before and after replacement of the corner pipes, as well as on days 1, 7, 14, 21 and 28 after installation of the HygieneSiphons.**

| Date | Time point | Place | Washbasin A | Washbasin B | Washbasin C |
|---|---|---|---|---|---|
| 31.7.15 | Before partial sanitization | Swab from drain trap | + | + | + |
| 14.11.15 | 7 days after partial sanitization (replacement of L-pipe with S-pipe)<br>1 day before installation of HygieneSiphons | Swab from drain trapon | – | – | +[1] |
| 16.11.15 | Day 1 after installation of HygieneSiphons | As per study design (see Fig. 4) In each case before and after filling the washbasin with water | – | – | – |
| 23.11.15 | Day 7 after installation of HygieneSiphons | | – | – | – |
| 30.11.15 | Day 14 after installation of HygieneSiphons | | – | – | – |
| 7.12.16 | Day 21 after installation of HygieneSiphons | | – | – | – |
| 14.12.16 | Day 28 after installation of HygieneSiphons | | – | – | – |

+ Isolation of 4MRGN (VIM) outbreak strain; – *P. aeruginosa* not isolated,
[1] Contact plate sample close to the drain immediately after filling and draining the water.

Table 2: Microbiology test results of swab from HygieneSiphon and of contact plate sample from washbasin after 3-month service life.

| Room | Swab from HygieneSiphon | Contact plate sample from washbasin |
|---|---|---|
| 1 | – | *Sphingomonas paucimobilis*, *Coagulase-negative staphylococci* |
| 2 | – | *Micrococcus spp.* |
| 3 | *Acinetobacter lwoffi* | *Pseudomonas stutzeri* |
| 4 | *Sphinomona paucimobilis* *Stenotrophomonas maltophilia* | – |
| 5 | – | *Stenotrophomonas maltophilia* |
| 6 | *Elisabethkingia sp.* | *Aeromonas sobria* *P. aeruginosa** |
| 7 (Washbasin A) | *Stenotrophomonas maltophilia* *P. aeruginosa* * | – |
| 8 (Washbasin B) | – | *Sphingomonas paucimobilis* |
| 9 | *P. aeruginosa**, *Stenotrophomonas maltophilia* | *Aerobic sporulating bacteria r* |
| 10 (Washbasin C) | *P. aeruginosa**, *Stenotrophomonas maltophilia* | – |
| 11 | *Stenotrophomonas maltophilia*, *P. aeruginosa**, *Sphingomonas paucimobilis* | *Stenotrophomonas maltophilia* |
| 12 | ***P. aeruginosa*** **4MRGN#** | ***P. aeruginosa*** **4MRGN#**, *Coagulase-negative staphylococci* |
| 13 | – | *Sphingomonas paucimolis* |
| 14 | *Stenotrophomonas maltphilia*, *Enterobacter cloacae* | – |
| 15 | ***Comamonas*** *sp.* | ***Comamonas*** *sp.* *Sphingomonas paucimolis* |
| 16 | – | – |

# Isolation of the 4MRGN outbreak strain; *Isolation of *P. aeruginosa* (non-4MRGN), – No bacterial growth.

Simulating the washing process, 4MRGN *P. aeruginosa* was isolated from the contact plate sample taken close to the drain trap of washbasin C after filling and emptying the basin (see Table 1, "+1").

That finding lends credence to the hypothesis that the washbasins were being contaminated with 4MRGN *P. aeruginosa* from the washbasin drain trap/siphon during wash training exercises.

All other contact plate samples of this test group were negative.

## Microbiology monitoring of the washbasins during the four-week service life of the HygieneSiphons

The results of all microbiology contact plate tests of the washbasin and swabbing tests of the aerator carried out under the aforementioned conditions on days 1, 7, 14, 21 and 28 after installation of the HygieneSiphons were negative for 4MRGN *P. aeruginosa*.

Since after four-week microbiology monitoring of the HygieneSiphon function 4MRGN *P. aeruginosa* was no longer detected when simulating the washing process, at the end of December 2015 the HygieneSiphons were installed in all 16 washbasins of patient rooms and the washbasins were released again for unrestricted patient use.

## Microbiology monitoring of the HygieneSiphons after three-month service life

Microbiology testing of the HygieneSiphons after three-month service life demonstrated that the majority of the inserted HygieneSiphons were colonized with bacterial flora (10 of 16 drain traps = 62.5%) (Table 2). Of the pathogens isolated the majority were non-fermenting water-associated bacteria, e.g. *P. aeruginosa*, *Acinetobacter lwoffii*, *Stenotrophomonas maltophilia*).

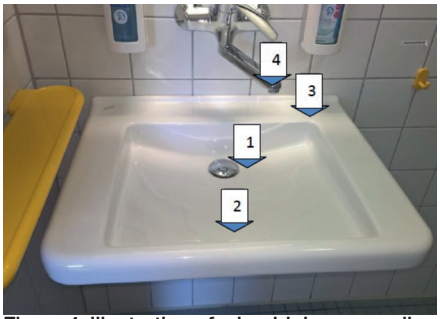


Figure 4: Illustration of microbiology sampling points.

1. Contact plate sample directly beside drain
2. Contact plate sample from front basin rim
3. Contact plate sample from rear basin rim
4. Swab from aerator.

In three rooms the pathogens isolated from the washbasin were identical to those from the HygieneSiphon, thus suggestive of pathogen regurgitation from the colonized HygieneSiphons.

The 4MRGN *P. aeruginosa* outbreak strain was isolated from one of the washbasins of these three rooms. That washbasin had tested negative for 4MRGN *P. aeruginosa* at the beginning of the study. An inquiry had revealed that a patient known to have been colonized with 4MRGN *P. aeruginosa* had been accommodated in that room since January 2016 and had given rise to secondary contamination of the washbasin and HygieneSiphon on using the basin. An overall appraisal of the test results suggest, we believe, that retrograde contamination of the HygieneSiphons from the waste water system was very unlikely.

### Patient screening after introduction of the HygieneSiphons

4MRGN *P. aeruginosa* belonging to the outbreak strain type was not detected when screening patients for MRGN up to six months after introduction of the HygieneSiphons.

## Discussion

To date, there have been frequent reports of *P. aeruginosa* and its multi-drug resistant variants as outbreak pathogens in the hospital setting [1, 4–10]. In addition to reports implicating the incoming water supply as the outbreak source, the focus is now increasingly on the waste-water systems [1, 4–7]. Biofilm formation can give rise to extremely high gram-negative bacteria concentrations in the waste water systems. Short L-shaped, horizontal waste pipes in combination with flat washbasins, as recommended and installed in rehabilitation clinics, are conducive to pathogen regurgitation into the wash water when filling the basin.

Our microbiology tests of washbasins and drain traps clearly confirmed retrograde contamination of the washbasins due to reflux of contaminated waste water when filling the washbasin. Installation of the HygieneSiphons was found to prevent pathogen reflux from the washbasin siphon trap into the washbasin. The marker organism used to that effect was 4MRGN *P. aeruginosa* known to colonize the siphon trap.

On using the HygieneSiphons it was possible to release for use again the washbasins in the patient rooms (including for wash training exercises).

During a six-month observation period following the introduction of the HygieneSiphons no instance of nosocomial colonization of patients with 4MRGN *P. aeruginosa* was noted.

Procurement of siphon (drain trap) heating systems was not a feasible alternative for the hospital. While siphon heating systems can reduce the pathogen density in waste water systems, they cannot in general fully eliminate the pathogens [11]. Besides, other drawbacks should be borne in mind, such as expedited corrosion of pipes and the high costs incurred for equipment procurement and maintenance.

The HygieneSiphons themselves can become contaminated over time by waste water. We therefore recommend observance of the HygieneSiphon service life specified by the manufacturer. The HygieneSiphon should be replaced even before the end of its service life as a component of terminal cleaning of a room after discharge of a patient colonised with multidrug resistant bacteria.

Drawbacks associated with HygieneSiphons include reduced draining velocity after filling the basin or also blockage if the washbasin is incorrectly used for waste disposal. The HygieneSiphon inlets can be easily replaced if blocked.

Installation of HygieneSiphons in washbasins represents an uncomplicated and cost efficient solution to effectively prevent pathogen reflux into the washbasin from colonized pipes. The HygieneSiphons are a good alternative to large-scale constructional sanitization of the waste water system.

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