Journal of Patient Care

Olivi et al., J Pat Care 2018, 3:3
DOI: 10.4172/2573-4598.1000134

Research Article Open Access

Antimicrobial Effectiveness of Rinse-Free Hospital Bathing Cleansers after 24 h of Initial Exposure to Common Pathogenic Micro-Organisms

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Received date: September 15, 2017; **Accepted date:** November 9, 2017; **Published date:** November 16, 2017

Abstract

Rinse-free disposable bathing clothes are increasingly more popular in the patient and home healthcare setting due to the antimicrobial properties, skin protection and convenience. Several rinse-free hospital bathing products are available for patient hygiene, but limited data exist regarding the comparative reduction in bioburden for epidemiologically important microorganisms causing hospital acquired infections. This study compared the antimicrobial effects of three common rinse-free hospital bathing cleansers. The antimicrobial effects of each cleanser (colloidal silver, benzalkonium chloride and methylpropanediol) were examined against ATCC bacterial strains (*E. coli*, VRE, MRSA) and one fungus (*C. albicans*). In addition, a patient derived sample of *C. albicans* and VRE was tested. With the exception of *E. coli*, across all test organisms and all cleansers, the Colloidal Silver solution sustained a substantially higher reduction in microbial growth proving after 24 h as an effective antimicrobial against multiple organisms including: MRSA, VRE, and *C. albicans*. Each pathogen presents unique risks to patients and challenges for the healthcare provider; therefore, the use of rinse-free bathing cleansers containing Colloidal Silver is warranted.

Keywords: Rinse-free bathing; Colloidal silver; Antimicrobial; Rinse-free bathing cleanser; Hospital acquired infection

Introduction

Antimicrobial stewardship is the organized effort to educate and influence antimicrobial providers to follow evidence-based prescribing, to stem antibiotic overuse, and thus antimicrobial resistance [1]. At hospitals, this may take the form of an antimicrobial stewardship program (ASP). Until recently, ASPs existed almost exclusively in the hospital setting, but due to antibiotic use in non-hospital settings greatly exceeding that in hospitals, led to implementation of ASPs across the health care field [2]. This is particularly seen within nursing facilities in the US, which provide medical and residential care for approximately 1.4 million persons on a daily basis and where infections are a common problem [3]. In light of this, recent revisions to regulations governing nursing facilities will require establishment of an ASP by November 2017 for participation in the Medicare and Medicaid programs [4].

Furthermore, traditionally chlorhexidine (CHG) has been a common, effective antiseptic used in healthcare facilities for disinfecting skin since the 1950's [5]. However, in 2015 the Association of perioperative Registered Nurses removed CHG from the standard practice protocol for pre-operative bathing for the prevention of surgical site infections [6]. As such, Kampf proposed establishing an 'Antiseptic Stewardship Initiative' citing research showing multiple microbial isolates are often CHG resistant [7]. In addition, the CDC recommendations for the prevention of surgical site infections moved CHG from a 1b recommendation to a "No Recommendation" [8]. Therefore, the need to find alternatives to CHG for patients in higher acuity settings is imperative.

As a result, to protect against healthcare associated infections (HAI's), rinse-free bathing cleansers are employed more frequently to fill this void in caring for intensive care, non-ambulatory and long-term care patients. Indeed, the skin is the largest organ of the body, therefore protecting skin integrity is an important factor in preventing microbial infections [9]. According to CDC National and State Healthcare-Associated Infections Progress Report, 2014, approximately one in 25 hospital patients have at least one HAI [10]. Healthcare associated infections confer excess cost to *healthcare* institutions and lead to substantial morbidity and mortality in hospitalized patients. Ensuring proper patient hygiene is one aspect of a cohesive approach to reduction in HAIs including central line, catheter-associated urinary and blood stream infections [11].

Several rinse-free hospital bathing products are available for patient hygiene, but limited data exists regarding the comparative reduction in bioburden for epidemiologically important microorganisms causing HAI's. Rinse-free disposable bathing clothes are increasingly more popular in the patient and home healthcare setting due to the antimicrobial properties, skin protection and convenience. Clinicians use rinse-free bathing cleansers on both intact and damaged skin caused by exposure to adhesives, incontinence, wound drainage, friction and pressure. This study takes a practical approach by evaluating the antimicrobial effectiveness of the cleanser coupled with the physical "Z" wiping motion similar to a method previously reported by Rutala [12]. The objective of this study was to evaluate the difference in bioburden reduction at 24 h among epidemiologically important organisms among three common rinse-free bathing cleansers.

Methods

This was an in-vitro hospital laboratory-based study evaluating the effectiveness in reducing the bioburden of three FDA approved rinse-free pre-packaged bathing cleansers: (i) A surfactant based formulation developed to sustain a skin pH based environment, containing colloidal silver (Colloidal Silver), (ii) A pH balanced formulation containing Benzalkonium chloride (Benzalkonium Chloride 0.12%), and (iii) A skin pH focused formulation containing methylpropanediol (Methylpropanediol) (Supplementary Data) . Test organisms include three bacterial and one fungal pathogen; *Escherichia coli*, (*E. coli* ATCC 25922), Vancomycin-resistant Enterococci (VRE ATCC 51299), Methicillin-resistant Staphylococcus aureus (MRSA ATCC 43300) and *Candida albicans* (*C. albicans* 10231), respectively. ATCC biological standard specimens were used to ensure reliability and quality control applications [13]. Two clinical isolates were also derived from hospital patients to demonstrate effectiveness using higher resistance organisms. In order to reduce variables of the bathing wipes material and viscosity, cleansing liquid was aseptically extracted from each bathing wipe and placed in sterile tube to ensure equal volume.

Laboratory methods

A confluent lawn of organisms was prepared using a 0.5 McFarland Standard for bacteria and a 2.0 McFarland Standard for yeast, on separate agar plates. Using aseptic technique, four 8 × 6 mm cellulose filters were soaked in 15 mL of one of each of the solutions (Colloidal Silver; Benzalkonium Chloride 0.12%; and Methylpropanediol) for 5 min.

Next, similar to a method previously reported by Rutala [12], a physical wiping "Z" pattern of approximately 6 cm total was streaked two times separately to ensure reliability in each quadrant of the agar plate. The "Z" streaking motion of approximately 6 cm total (following a template) was made twice in each quadrant of the agar plate (Supplementary Figure 1). This represents the wiping pattern used when cleansing a patient swiping one time over the skin rather than repeating over the same area. This was repeated for each of the test microorganisms with each of the bathing cleansers. Plates were incubated at 37°C for 24 h to assess for zones of inhibition and analyzed for reduction in microbial growth.

Results

Overall, the Colloidal Silver solution demonstrated a substantially higher percentage reduction in every microorganism tested with the exception of *E. coli* (Figure 1). Methylpropanediol demonstrated kill power in *C. albicans* and MRSA. Benzalkonium Chloride demonstrated kill power *C. albicans*, MRSA, *E. coli* and VRE. The results are summarized in (Figure 1 and Table 1) as follows:

C. albicans patient derived: The Colloidal Silver solution demonstrated a significantly higher reduction (56.2%) in fungal growth at 24 h with Methylpropanediol and Benzalkonium Chloride at 8.6% and 7.3%, respectively.

C. albicans ATCC 10231: The Colloidal Silver solution demonstrated the highest percentage reduction (54.8%) in fungal growth in at 24 h with Methylpropanediol (9.7%) and Benzalkonium Chloride (12.8%).

E. coli ATCC 25922: The Benzalkonium Chloride solution demonstrated the highest percentage reduction (6.3%) in growth followed by Colloidal Silver solution (3.0%). Methylpropanediol solution showed no reduction.

MRSA ATCC 43300: The Colloidal Silver solution demonstrated the highest percentage reduction (29.8%) in microbial growth at 24 h with Benzalkonium Chloride (18.9%) Methylpropanediol (4.8%).

VRE patient derived: The Colloidal Silver solution demonstrated the only microbial reduction (66.4%) at 24 h. No reduction in Benzalkonium Chloride or Methylpropanediol solution.

VRE ATCC 51299: The Colloidal Silver solution demonstrated the highest percentage reduction (28.1%) and Benzalkonium Chloride (5.6%). Methylpropanediol solution showed no reduction.

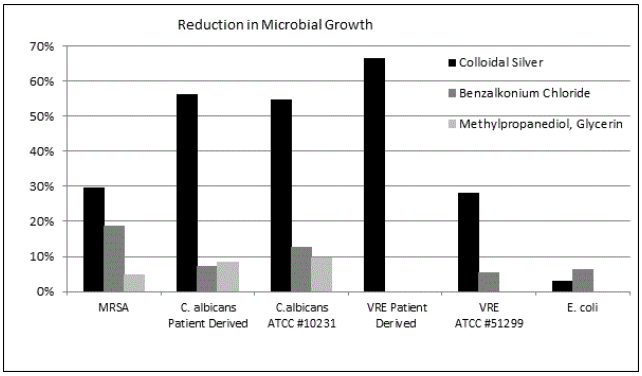

Figure 1: Depicts percentage reduction in microbial growth for each organism and each cleansing solution.

Discussion

Without a doubt, ensuring appropriate and routine patient cleansing is an important factor in preventing high risk HAI's [14]. Thus, the aim of this study was to investigate rinse-free bathing cleansers which sustain antimicrobial effectiveness of multiple clinically isolated pathogens for an extended time.

We utilized a novel in-vitro methodology and the overall results indicate the Colloidal Silver solution reduced growth in all the bacterial and fungal organisms tested at 24 h. Furthermore, in five out of the six organisms, Colloidal Silver demonstrated a substantially higher rate of antimicrobial effectiveness after 24 h when compared to the Benzalkonium Chloride and Methylpropanediol solution. Although Benzalkonium Chloride and Methylpropanediol demonstrated antimicrobial effectiveness, the percentage reduction was substantially lower compared to the Colloidal Silver solution.

These results are corroborated within the literature; in the case of *C. albicans*, Gajbhiye show nano particle silver enhances the inhibitory effect of fluconazole [15]. The efficacy against MRSA is substantiated in the literature by Ansari, where they used confocal laser scanning techniques to examine anti-biofilm activity of a silver nano particle coating for medical devices [16]. However, not all products enhanced with silver result in the same benefit; for example with VRE we see a growth reduction, which is substantiated by Tran [17], however, Boonkaew saw an apparent promotion of VRE [18] with the silver enhanced formulation they examined. Thus, formulation differences have a big impact on anti-microbial efficacy between the silver-enhanced products. Additionally, although the literature lacks evidence

supporting widespread silver resistance, it remains of interest warranted by the existence of clinically isolated silver resistance genetic determinants [19].

Treatment	Test Microorganism					
Rinse-free bathing solution	*C. albicans* Patient Derived	*C. albicans* ATCC 10231	*E. coli* ATCC 25922	MRSA ATCC 43300	VRE Patient Derived	VRE ATCC 51299
	% Reduction in Growth Area at 24 h					
Colloidal Silver Cleanser	56.2	54.8	3	29.8	66.4	28.1
Benzalkonium Chloride 0.12%	7.3	12.8	6.3	18.9	0	5.6
Methylpropanediol	8.6	9.7	0	4.8	0	0

Table 1: Reduction in bacterial and fungal growth at 24 h.

Another aspect of these cleansers is the application site, the skin. The key mechanism of epidermal protection is now generally accepted to localize to the stratum corneum [20]. The stratum corneum serves multiple protective functions including: permeability, anti-oxidation, hydration, limiting pathogen colonization, and more [21]. Therefore, improving the integrity of the skin is equally as important as the antimicrobial solution applied to the skin. And this is where other factors within the formulations of each of these products may provide additional benefits to those observed within this *in vitro* study. Based on the data outcomes of this study, the next phase will involve patient evaluation.

Conclusion

With antimicrobial and antiseptic stewardship becoming the norm within the healthcare landscape, the requirement for alternative approaches for preventing high risk hospital acquired infections comes to the fore. Based on the findings of this study, rinse-free bathing cleansers are not all the same when evaluating duration of antimicrobial effectiveness across multiple pathogens. With the exception of *E. coli* ATCC 25922, across all organisms and all rinse-free bathing cleansers tested, Colloidal Silver solution demonstrates to be a more effective antimicrobial after 24 h against multiple common hospital infections including: MRSA, VRE and *C. albicans* than other rinse-free bathing cleansers.

Overall, the Colloidal Silver solution demonstrated a substantially higher reduction in every microorganism tested with the exception of *E. coli*.

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