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Efficacy and Safety of Polyhexanide (PHMB)-Based Irrigation Solutions for Catheter Flushing in the Prevention of Catheter-Associated Urinary Tract Infections: A Literature Review

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ABSTRACT

Introduction: Catheter-associated urinary tract infections (CAUTIs) are common in patients with long-term catheterization, mainly due to biofilm formation on the catheter surface. Biofilms reduce the effectiveness of systemic antibiotics and standard flushing. Polyhexanide (PHMB) is a broad-spectrum antiseptic proposed as an irrigating solution to address these issues. Objectives: To review current literature on 0.02% PHMB irrigation in the prevention of CAUTI and maintenance of indwelling urinary catheters (IUC). Methods: A narrative review was performed using PubMed, Google Scholar, ScienceDirect, and supplementary sources for studies up to May 2025. Inclusion criteria were experimental and clinical studies assessing PHMB irrigation in catheterized patients or catheter models. Four studies met the criteria: two in vitro and two clinical. Results: In vitro: 0.02% PHMB significantly reduced biofilm and colony formation on catheter materials compared with saline or no treatment ($p < 0.01$). Clinical: In 74 chronically catheterized patients, PHMB irrigation was well tolerated, with no serious adverse events and only mild, transient local symptoms. Some patients reported fewer catheter blockages, odor, and discomfort. However, trials lacked randomization, had short follow-up periods, and reported limited microbiological outcomes, which restricted their generalizability. Conclusions: Irrigation with 0.02% PHMB appears to be a safe modality for reducing biofilm and maintaining the catheter. Preliminary clinical data demonstrate good patient acceptance; however, well-designed, randomized controlled trials with long-term follow-up are needed to confirm efficacy and determine the optimal regimen.

Keywords: Polyhexanide irrigation, Catheter-associated urinary tract infections, PHMB flushing, Antimicrobial catheter care, Biofilm reduction, CAUTI prevention

1. INTRODUCTION

Catheter-associated urinary tract infections (CAUTI) are one of the most frequent types of healthcare-associated infections, whose incidence rates are significant causes of both patient morbidity and mortality as well as healthcare costs. In the United States alone, more than 560,000 cases of hospital-acquired urinary tract infections (UTIs) take place each year, with a total of over 13,000 deaths attributable to these statistics. In 2.3% of cases, fatality rates were recorded (Klevens et al., 2007). Such infections occur mostly in patients who need long-term urinary catheterization or who have urinary retention, neurogenic bladder, or are in poor health and thus at much greater risk from other conditions (Forde et al., 2018; Stickler et al., 2010).

A major cause of CAUTI, according to one of those we spoke with who are experts in the field, is the formation of microbial biofilms on the surfaces of catheters. Containing bacteria, proteins, and urine matter, biofilms are structured community types resistant to standard antimicrobial drugs (Jamal et al., 2018). Catheters encrusted with biofilm often yield such organisms as Escherichia coli, Pseudomonas aeruginosa, Proteus mirabilis, Enterococcus faecalis, Staphylococcus aureus, and various Candida species. The thickness of a biofilm can reach more than 400 cells, and its depth may be as great as 490 μm. The net result is that such structural forms make it difficult to remove the biofilm through conventional catheter flushing and therapeutically formal antimicrobial agents.

Biofilms are known to be up to 1500 times as resistant to antibiotics as are planktonic bacteria, which makes for serious management difficulties in successfully treating an infection and often leads to catheter blockage. One is encrustation reduced quality of life (Stickler et al., 2010; Tenke et al., 2012). With the modest efficacy of systemic treatment, local prophylactic measures, such as catheter irrigation, have been receiving more and more attention. These crystals, debris, and minerals are dissolved by traditional irrigants such as citric acid solutions, but there is conflicting evidence to support their efficacy and their tolerability (Smith et al., 2003).

Polyhexanide (PHMB), a polycationic biguanide derivative formulated as a second-generation chlorhexidine analog, has been identified to possess appealing antimicrobial properties. PHMB has a broad spectrum of activity, active against bacteria, fungi, and protozoa, and has low cytotoxic effect and no development of resistance (Saleh et al., 2016). Polyhexanide (PHMB) has a track record as an antiseptic for wound treatment and irrigation. More recently, its possible use in urology has been investigated, in particular in flushing long-term indwelling devices such as catheters to try to prevent biofilm growth and decrease risk for catheter-related urinary tract infections (CAUTI) (Brill et al., 2018).

This review aims to evaluate the evidence about the efficacy and safety of PHMB-based irrigation solutions as a preventive strategy for CAUTI in IUCD patients.

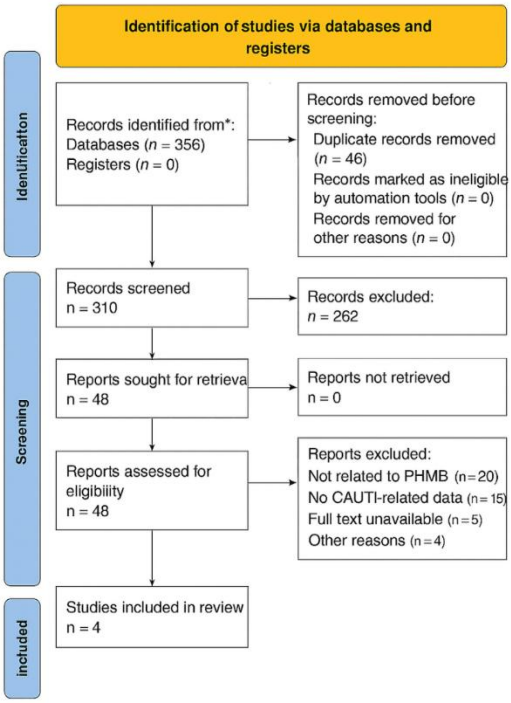

Figure 1 PRISMA 2020 flow diagram illustrating the selection process for studies included in the systematic review on PHMB irrigation.

2. REVIEW METHODS

This literature review was conducted in accordance with the standard procedure for synthesizing narrative evidence in the medical field. The search strategy aimed to identify original studies on the use of polyhexanide (PHMB)-containing irrigation solutions for prevention of CAUTIs.

A systematic literature search was carried out in openly accessible databases such as PubMed, Google Scholar, and ScienceDirect. To ensure broader coverage, additional searches were undertaken through platforms like ResearchGate and SciSpace, as well as on selected publishers' websites, including BMC and Springer Nature.

The search covered articles published up to May 2025, using combinations of the following keywords: polyhexanide, PHMB, catheter irrigation, CAUTI (catheter-associated urinary tract infection), biofilm, antimicrobial irrigation, and catheter flushing. The review included original studies published in English that reported clinical, observational, or in vitro findings on the application of PHMB for urinary catheter irrigation or maintenance. Both patient-based research and experimental models simulating catheterization and biofilm formation relevant to CAUTI pathogenesis were considered. Only studies with full-text availability were eligible for inclusion. After initial screening of titles and abstracts, four original studies were selected for in-depth analysis. The selection process followed the PRISMA 2020 guidelines, and the detailed flow of records, from identification to exclusion and inclusion, is presented in the PRISMA flow diagram (Figure 1).

3. RESULTS & DISCUSSION

This literature review was conducted in accordance with the principles of narrative evidence synthesis in medical research. In half of our sample, the procedure of PHMB irrigation via urethral catheterization gave rise to pruritus (Pannek and Wiseman, 2020; Wiseman, 2023), and more than one-third brought complainants into home-style hospitals for permanent catheters (Wiseman, 2023). Four original studies were chosen for full-text review following the screening of titles and abstracts (Table 1). These publications covered clinical safety and tolerability in catheterized patients (Pannek and Wiseman, 2020; Wiseman, 2023); the potential of PHMB irrigation to reduce biofilm formation on catheter surfaces (Brill et al., 2018; Brill et al., 2021); its capability for decolonizing under laboratory conditions (Brill et al., 2018); and patient-reported experiences with long-term catheter maintenance (Wiseman, 2023).

This review of the literature summarizes the existing evidence on polyhexanide (PHMB)- type irrigation solutions for maintaining indwelling urinary catheters, with a particular focus on the prevention of CAUTIs. The studies analyzed are in agreement, but discontinuous: both the outcome and surgical safety profile of a 0.02% PHMB solution in vitro and clinical practice vary greatly (Brill et al., 2018; Brill et al., 2021; Pannek and Wiseman, 2020; Wiseman, 2023) (Table 1).

Brill et al., (2018; 2021) in vitro tests involving many kinds of urethral catheters — silicone, hydrogel-coated, latex-free, and PVC models — show significantly decreased bacterial biofilm densities. Such findings support the antimicrobial capacity of PHMB. This compound can destroy in vitro established biofilms of uropathogenic bacteria that are similar to those found in clinical settings, such as E. coli or P. aeruginosa. Following PHMB treatment, the number of viable bacteria fell in line with expectations, along with statistical significance. This implies that PHMB has substantial decolonizing potential even under conditions that mimic clinical use (Brill et al., 2018; Brill et al., 2021) (Table 1).

Pannek and Wiseman (2020) cohort study and the observational research reported by Wiseman (2023) both showed good safety results. Microbiologically, there were no serious adverse events attributable to PHMB instillations. On the other hand, Wiseman's (2023) study also presented qualitative data about patient comfort, fewer catheter blockages, and reduced urine odors, all of which can positively affect the quality of life (Table 1). Both agents reduced bacterial load simply by mechanically rinsing them off the surface. PHMB's antimicrobial performance outperformed those biofilms beyond the reach of NaCl alone to clear out. This supports the hypothesis that PHMB has a dual effect: physical clearance and antimicrobial action (Brill et al., 2021).

While we must admit significant differences existed between the studies, the promising results should not be dismissed. Due to this methodological heterogeneity — ranging from in vitro models to small-scale, non-randomized clinical trials — findings cannot be generalized. Moreover, none of the clinical studies reported the duration of observation or established both blinded assessment and control groups. Undoubtedly, sample sizes were relatively small ($n < 60$), and all studies failed to employ standardized outcome measures or to provide objective diagnostic criteria for CAUTI (Wiseman, 2023).

By and large, included research tended to maintain moderate levels of quality. These studies did not declare a particular quality evaluation scheme or adhere strictly to one. It is hoped that continued research can eventually overcome this problem. Some of the methodological differences between them may be sources of bias: self-reported outcomes or limited long-term tracking, for instance,

restrict our interpretation of significant findings. Yet the collected evidence strongly suggests that a 0.02% PHMB solution is a safe and well-tolerated adjunct to preventing CAUTIs or maintaining indwelling catheters (Brill et al., 2018; Brill et al., 2021; Pannek and Wiseman, 2020; Wiseman, 2023) (Table 1). The findings urge large-scale, randomized controlled trials with standardized protocols and longer follow-up periods as well as cost-effectiveness assessments to assess the clinical utility of PHMB.

Table 1: Summary of studies evaluating the use of 0.02% polyhexanide (PHMB) irrigation for urinary catheter flushing.

Study (Author, Year)	Study Design	Type of Intervention	Population	Comparator	Efficacy Findings	Safety Findings	Authors ' Conclusions
Pannek and Wiseman, 2020	Prospective cohort, multicenter	Bladder irrigation with 0.02% PHMB, daily for 5 days	33 long-term catheterized patients (mostly male, mean age 73)	None	No significant change in lab values or vital signs. Clinical symptoms (e.g. flushing) were mild and transient.	No serious AEs; mild, self-limited events in 45%. Well tolerated.	PHMB irrigation was safe and well tolerated; further trials on efficacy and long-term safety warranted.
Brill, 2021	In vitro laboratory study	In vitro flushing of 5 catheter types with 0.02% PHMB for 60 s after artificial biofilm formation	NA	0.9% NaCl and no irrigation	PHMB significantly reduced biofilm formation vs. no treatment ($p = 0.011$); better than NaCl, but not statistically significant ($p = 0.074$)	Not assessed	PHMB showed promising antibiofilm effect. Clinical studies are needed to validate in vivo applicability.
Brill, 2018	In vitro laboratory study	In vitro flushing of pre-colonized catheters with 0.02% PHMB (5 ml, 60 s)	NA	0.9% NaCl and no irrigation	PHMB significantly reduced CFU counts vs. no treatment ($p = 0.002$); effect stronger than NaCl but not statistically significant ($p = 0.074$)	Not assessed	PHMB and NaCl both reduced colonization, but PHMB showed better potential; further clinical studies required.
Wiseman, 2023	Retrospective user experience	PHMB-based irrigation, twice weekly for 5 weeks	42 patients with indwelling catheters >30 days	None	Improved comfort, reduced leakage, blockages, odor, and possible CAUTI reduction	5% reported mild, transient bladder discomfort	PHMB irrigation may reduce CAUTI risk and improve QoL. Acceptable tolerability and ease of use; further research needed.

In summary, bladder irrigation with polyhexanide (PHMB) is a promising approach to managing indwelling urinary catheters, which brings both antimicrobial effectiveness as well as patient-related benefits. This existing body of evidence, although limited and largely exploratory, nonetheless provides some basis for such preventive interventions deserving more emphasis in future rigorous research.

4. CONCLUSION

Except the cited subjective testimony concerning catheter blockage, the application of 0.02% polyhexanide (PHMB) as an irrigation solution for indwelling urinary catheters seems to have been first proper and secondly successful in preventing catheter-related infections. In vitro evidence shows that there is a significant reduction of biofilm. Clinical results, however, suggest that patients accept the irrigation treatment quite well and might derive some benefit from it in terms of avoiding more than an occasional catheter blockage a year along with increased comfort. Conversely, the number of studies was limited, their sample sizes were small, and there were no randomized controlled trials. These factors restrict the strength of current evidence. As a consequence, further large-scale, high-quality clinical trials are needed to confirm efficacy and work out standardized irrigation protocols.

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Informed consent

Not applicable.

Ethical approval

Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

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Conflict of interest

The authors declare that they have no conflicts of interests, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data and materials availability

All data associated with this study will be available based on the reasonable request to corresponding author.

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