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Review Article

Bacterial regrowth following various surgical scrubbing methods in prolonged surgeries

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ABSTRACT

Bacterial regrowth beneath surgical gloves during prolonged operations remains a critical challenge in infection prevention. While surgical scrubbing methods effectively reduce microbial load at the start of procedures, the persistence and reappearance of skin flora over time can compromise the sterile field, especially during glove changes or unnoticed micro-perforations. The type of antiseptic agent, its residual activity, and the duration of the procedure influence how rapidly bacteria recolonize the hands. Alcohol-based hand rubs offer rapid initial reduction but may lack prolonged antimicrobial activity, while chlorhexidine and povidone-iodine formulations exhibit longer-lasting effects due to their ability to bind to the skin. Environmental conditions under gloves such as moisture, heat, and friction further contribute to microbial resurgence. The skin's natural characteristics, including the presence of deep-seated resident flora and the integrity of the skin barrier, also shape the rate of regrowth. Studies indicate that even with strict adherence to antisepsis protocols, bacterial levels under gloves can approach pre-scrub levels after several hours of wear. This risk is heightened in long surgeries where intraoperative interventions are limited. Infection control strategies must evolve to include time-based glove changes, selection of antiseptics with sustained activity, and intraoperative hygiene protocols when necessary. Institutional policies often overlook regrowth dynamics, focusing solely on preoperative practices. A more dynamic model that accounts for intraoperative changes and incorporates evidence-based antiseptic selection can reduce the risk of surgical site contamination. Understanding the multifactorial nature of bacterial regrowth and addressing it through procedural, environmental, and product-based adjustments is essential for maintaining surgical sterility in extended operations.

Keywords: Bacterial regrowth, Surgical scrubbing, Prolonged surgeries, Hand antisepsis, Infection control

INTRODUCTION

Surgical site infections (SSIs) remain a significant cause of morbidity and healthcare burden despite ongoing advances in sterile techniques and antimicrobial practices. One of the critical control measures in preventing SSIs is effective surgical hand antisepsis. The primary goal of surgical scrubbing is to reduce the transient and resident bacterial flora on the hands of surgical personnel to prevent contamination of the sterile field during operative procedures. However, the efficacy of different scrubbing techniques may diminish over time, particularly in prolonged surgeries where bacterial regrowth can occur despite initial decontamination.

Surgical scrubbing methods generally fall into two main categories: traditional hand scrubbing using antimicrobial soap and water, and waterless hand rubs based on alcohol formulations. Both have demonstrated effectiveness in reducing initial microbial counts, yet differences emerge in terms of skin tolerance, speed of application, and residual antimicrobial activity.[1] Alcohol-based hand rubs are increasingly favored for their broad-spectrum bactericidal activity and rapid action, but their duration of residual effectiveness remains a point of contention when surgeries extend for several hours.[2] Conversely, antimicrobial soaps like chlorhexidine gluconate and povidone-iodine exhibit longer-lasting antimicrobial action through their binding to the skin, which can help suppress regrowth during extended procedures.[3]

The challenge of bacterial regrowth becomes more critical in lengthy operations, especially when surgical gloves are compromised or micro-perforations develop over time. The combination of increased skin moisture, perspiration, glove movement, and mechanical stress may provide favorable conditions for bacterial resurgence. Even when gloves remain intact, the regrowth of skin flora under the occlusive environment can reach levels that approach pre-scrub baselines after several hours, increasing the risk of contamination during glove changes or accidental breaches in sterile technique.[4]

REVIEW

Bacterial regrowth during prolonged surgical procedures remains a concern, even after proper preoperative hand antisepsis. While initial bacterial reduction is achieved with both antimicrobial soaps and alcohol-based rubs, studies suggest that microbial counts can rebound significantly over time, especially when the residual activity of the product is weak or absent. The risk is compounded in lengthy surgeries, where glove integrity may be compromised, increasing the chances of microbial transfer. A comparative study found that chlorhexidine-based products were more effective in maintaining suppressed bacterial levels over extended durations compared to alcohol-only formulations, due to their persistent antimicrobial action on the skin.[5] Additionally, the physical and chemical environment under surgical gloves, including heat and perspiration, fosters an ideal setting for bacterial proliferation despite initial antisepsis. This can potentially lead to contamination during glove changes or unnoticed micro-perforations, particularly in high-risk surgeries.[6] Continuous exposure to antiseptic agents may also contribute to skin barrier breakdown, which not only facilitates regrowth but may also affect compliance among surgical staff due to discomfort or irritation. Therefore, the choice of scrubbing method must consider both the immediate and long-term efficacy of bacterial suppression in extended operative settings.

EFFICACY OF SCRUBBING IN LONG SURGERIES

The effectiveness of surgical scrubbing in extended procedures depends on multiple factors, including the antimicrobial agent used, duration of application, and the product's ability to provide lasting protection under occlusive environments. Traditional scrubbing methods, often involving chlorhexidine or povidone-iodine solutions, have long been used for their immediate microbial reduction. Yet in surgeries that exceed two hours, the duration of antimicrobial activity becomes a determining factor in preventing microbial rebound beneath gloves. Alcohol-based hand rubs are highly effective for rapid decontamination but are often questioned for their limited residual action, especially when compared to agents that bind to skin and release over time.[7]

Prolonged operations increase the likelihood of glove micro-perforations, unnoticed by the surgical team, allowing for potential leakage of bacteria that may have regrown during the procedure. Studies have demonstrated that regrowth of skin flora beneath gloves can reach significant levels within 90 minutes, even following proper antiseptic preparation. In tests comparing various scrubbing agents, products combining alcohol with chlorhexidine showed greater bacterial suppression beyond the initial scrub phase, suggesting that formulations with both rapid and residual effects may offer superior protection in lengthy procedures.[8] Hand moisture and warmth under gloves influence regrowth dynamics.

Occlusion creates a microenvironment where residual antiseptic activity is challenged by sweat, friction, and heat. These factors can compromise the barrier function of the skin, diminish the effectiveness of antiseptic binding and contribute to microbial persistence. Furthermore, extended gloving contributes to skin maceration, which alters the surface characteristics of the skin and may facilitate bacterial survival or resurgence. Unlike shorter surgeries, where the duration of microbial suppression from a scrub may outlast the procedure, long operations test the limits of a product's residual activity and the integrity of the skin's protective capacity. Scrub duration and thoroughness can vary among individuals, affecting the consistency of antimicrobial coverage. A

time-based approach, such as the widely recommended 3 to 5-minute scrub, may not guarantee uniform microbial suppression if friction, drying time, or product volume are insufficient. Evidence from controlled trials has suggested that standardizing scrubbing protocols with validated formulations, particularly those with persistent effects, is more impactful than simply increasing scrub duration.[9] The interaction between technique and formulation quality becomes more apparent when observing outcomes in high-risk surgical environments.

Hand antisepsis products are also influenced by cumulative usage over multiple procedures. With repeated exposure, skin tolerance plays a role in product selection. Frequent use of harsh antiseptics can lead to dermatitis or micro-abrasions, inadvertently creating more favorable sites for bacterial habitation. This is especially relevant for surgical teams engaged in multiple back-to-back procedures within a single shift. A study evaluating different formulations found that alcohol-based scrubs enriched with emollients-maintained skin integrity more effectively than traditional soap-based scrubs, while still delivering adequate bacterial control over extended periods.[10]

DRIVERS OF BACTERIAL REGROWTH

Bacterial regrowth following surgical hand antisepsis is shaped by a combination of microbial behavior, host skin conditions, and procedural factors. While the initial microbial reduction may be effective, the skin's complex microenvironment begins to shift once occlusion, heat, and moisture accumulate under gloves. Within this sealed setting, residual antiseptic action begins to taper off, particularly when the product lacks substantivity or fails to bind effectively to the stratum corneum. This environment not only favors recolonization but also influences the rate at which both transient and resident flora recover their populations over time.[11]

The physiology of the skin plays a central role in this process. Sebaceous glands and sweat ducts contribute to microbial regrowth by acting as reservoirs that antiseptic agents may not fully penetrate. Bacteria such as *Staphylococcus epidermidis* and *Corynebacterium* spp. are deeply embedded in the layers of the skin, resistant to temporary surface-level elimination. With time, these organisms re-emerge, especially in warm, moist conditions created during long surgical cases. Studies have highlighted that even with repeated scrubbing, deeper bacterial layers remain largely unaffected and can resurface quickly once conditions allow.[12] This creates a feedback loop in which suppression is temporary and regrowth begins from residual dermal flora. Glove wear time has also been linked to regrowth acceleration. Even in the absence of visible glove failure, the friction between glove and skin combined with prolonged occlusion encourages the return of microorganisms. Increased sweating under gloves raises hydration levels on the skin, diminishing the antiseptic barrier and providing a suitable surface for bacterial replication. In procedures exceeding three hours, glove-associated changes in skin pH and moisture become more pronounced, often correlating with elevated colony-forming units when measured at glove removal. These findings support the idea that the effectiveness of scrubbing agents should not only be evaluated at the point of application but across the time continuum of actual surgical conditions.[13]

Human variability adds further complexity to the issue. Skin type, hydration status, previous antiseptic exposure, and the presence of micro-abrasions all influence how skin flora behaves post-scrubbing. For instance, individuals with dry or compromised skin may experience faster rebound due to decreased antiseptic retention and a weaker skin barrier. Behavioral components such as improper drying time or incomplete coverage during application also contribute, especially under time pressures in fast-paced surgical settings. Product formulation, though often the focus, cannot fully offset lapses in technique or variability in individual skin responses.

Microbial adaptation cannot be ignored. Over time, repeated exposure to certain antiseptics, particularly those used frequently in high-volume centers, may contribute to reduced susceptibility among resident skin flora. Although not classified as resistance in the traditional antimicrobial sense, lowered effectiveness of commonly used agents such as triclosan or povidone-iodine has been observed in some clinical isolates. The relevance of such trends becomes more apparent when regrowth rates increase despite adherence to protocol, suggesting the need for periodic evaluation of antiseptic efficacy in the face of evolving microbial populations.[14]

INFECTION CONTROL IMPLICATIONS

The persistence of bacterial regrowth during prolonged surgeries introduces multiple layers of complexity into infection control protocols, especially in high-risk operative environments. Hand antisepsis, often seen as a standalone step in preoperative routines, must be understood as part of a broader, continuous strategy. When hand flora resurfaces after scrubbing, even under gloves, it compromises the intended sterility of the field, especially during glove changes or unnoticed breaches. This risk becomes particularly relevant in surgeries lasting more than two hours, where bacterial counts under gloves may return to near pre-scrub levels by the end of the procedure. Infection control practices that fail to account for intraoperative regrowth are operating under an incomplete model of microbial risk.[15] Long surgeries require sustained strategies rather than reliance on a single scrub event. This shifts the focus from product selection alone to procedural adaptations, such as timed glove changes, use of double gloving, and enhanced protocols for re-scrubbing during extended cases. Some surgical teams implement intraoperative hand hygiene

during glove changes, particularly in transplant or orthopedic procedures where the risk of deep infections is high. While such practices may not be routine across all surgical fields, evidence suggests their effectiveness in minimizing contamination from regrowth-associated flora, especially in moments where sterility is momentarily interrupted.[16]

Product design also intersects with infection control policy. Antiseptics with both immediate kill and residual protection are better suited for lengthy operations, yet institutional procurement decisions often prioritize cost or supplier agreements over duration-specific performance. A study comparing chlorhexidine-alcohol combinations with povidone-iodine-based scrubs found not only superior bacterial reduction immediately post-scrub, but also slower regrowth under gloves after three hours of wear. Hospitals that integrated such data into their purchasing policies observed lower surgical site infection rates over time. However, the lag between research evidence and protocol change continues to be a barrier in many systems, where antiseptic selection remains static despite evolving operative demands.[17]

Environmental conditions in operating rooms can also influence regrowth patterns. Temperature, humidity, and glove material all play subtle but measurable roles in altering skin moisture and friction, both of which affect how quickly flora returns. Research exploring surgical environments with regulated humidity showed slightly reduced regrowth rates, suggesting that even small changes in climate control may assist in broader infection control efforts. Attention to such details offers valuable insight into how multidisciplinary coordination can reduce intraoperative microbial load and strengthen existing sterile protocols.[18]

CONCLUSION

Effective surgical hand antisepsis must be viewed as an ongoing process rather than a single preoperative step. Bacterial regrowth during prolonged procedures presents a tangible risk to surgical sterility. Scrubbing methods, glove protocols, and intraoperative hygiene all play interconnected roles. Addressing these factors collectively strengthens infection control and enhances patient safety.

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REFERENCES

1. Rotter ML, Sattar SA, Suchomel M. Methods to evaluate the antimicrobial efficacy of hand hygiene agents. Hand hygiene: A handbook for medical professionals. 2017:58-69.
2. Widmer AF. Replace hand washing with use of a waterless alcohol hand rub. Clin Infect Dis. 2000;31(1):136-43.
3. Mayhall CG. Hospital epidemiology and infection control. Lippincott Williams & Wilkins. 2012.
4. Ma Y, Yue X, Li N. Evaluation of an intervention to improve waterless surgical hand antisepsis accuracy in a tertiary hospital of East China: a prospective pre-post intervention study. Front Pub Health. 2025;13:1583510.
5. Parienti JJ, Thibon P, Heller R. Hand-rubbing with an aqueous alcoholic solution vs traditional surgical hand-scrubbing and 30-day surgical site infection rates: a randomized equivalence study. JAMA. 2002;288(6):722-7.
6. Kampf G, Kramer A. Epidemiologic background of hand hygiene and evaluation of the most important agents for scrubs and rubs. Clin Microbiol Rev. 2004;17(4):863-93.
7. Block SS. Disinfection, sterilization, and preservation. Lippincott Williams & Wilkins. 2001.
8. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Infect Cont Hospital Epidem. 2002;23(12):3-40.
9. Li L, Wang Y, Wang S. Efficacy comparison of chlorhexidine and iodine preparation in reduction of surgical site infection: a systemic review and meta-analysis. Int J Nursing Studies. 2022;127:104059.
10. Dharan S, Hugonnet S, Sax H, Pittet D. Comparison of waterless hand antisepsis agents at short application times: raising the flag of concern. Infect Cont Hosp Epidemiol. 2003;24(3):160-4.
11. Price PB. The bacteriology of normal skin; a new quantitative test applied to a study of the bacterial flora and the disinfectant action of mechanical cleansing. J Infect Dis. 2017;19:301-18.
12. Aly R, Malbach HI. Comparative antibacterial efficacy of a 2-minute surgical scrub with chlorhexidine gluconate, povidone-iodine, and chloroxylenol sponge-brushes. American J Infect Cont. 1988;16(4):173-7.
13. Suchomel M, Fritsch F, Kampf G. Bactericidal efficacy of two modified WHO-recommended alcohol-based hand rubs using two types of rub-in techniques for 15s. J Hospital Infection. 2021;111:47-9.
14. McDonnell G, Russell AD. Antiseptics and disinfectants: activity, action, and resistance. Clin Microb Rev. 1999;12(1):147-79.
15. Wistrand C, Söderquist B, Falk-Brynhildsen K, Nilsson U. Exploring bacterial growth and recolonization after preoperative hand disinfection and surgery between operating room nurses and non-health care workers: a pilot study. BMC Infect Dis. 2018;18(1):466.

16. Widmer A, Rotter M, Voss A. Surgical hand preparation: state-of-the-art. J Hospital Infect. 2010;74(2):112-22.
17. Al-Naami MY, Anjum MN, Afzal MF. Alcohol-based hand-rub versus traditional surgical scrub and the risk of surgical site infection: a randomized controlled equivalent trial. EWMA J. 2009;9(3):769.
18. Dharan S, Pittet D. Environmental controls in operating theatres. J Hospital Infect. 2002;51(2):79-84.

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