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Blood Donor Arm Cleaning–Another Step towards Preventing the Contamination of Blood Products for Transfusion Purposes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Blood Establishments strive to provide blood and blood derivatives that are safe for transfusion. A recurrent concern is providing blood components that are free from bacterial contamination. Bacterial and fungal contamination of blood products is nowadays a major apprehension when it comes to transfusion adverse events. Over the years, several disinfection products and protocols have been devised to mitigate the risks of such contaminants, nonetheless, sepsis is still the leading cause of transfusion reaction fatalities. This fact raises the question of whether disinfection on its own is sufficient for preventing such outcomes.

Keywords: Contamination; blood products; blood donor; disinfection; cleaning.

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1. INTRODUCTION

Blood establishments developed several preventive measures to avert this unwanted entry of bacteria into the bloodstream from happening. A very important measure in preventing this is how the skin is disinfected before blood collection [1]. Inadequate or ineffective disinfection is one of the main sources of bacterial contamination of blood products [2]. Over the years, several disinfection products and protocols have been devised, however, sepsis is still the leading cause of transfusion reaction fatalities [3]. Several factors could affect the efficacy of disinfection which increases the likelihood of contaminated blood products. It is being proposed that cleaning the skin before blood donation increases the effectiveness of the disinfection process [4].

2. CAUSES OF FAILED DISINFECTION

2.1 Bacterial Load on the Skin

The skin harbours a diverse microbiome, some of which have a symbiotic relationship with the skin itself [5]. It has been shown that the higher the bacterial load on the skin, the less effective skin disinfection is [6]. The greater the bacterial load on the skin, the more contact time is required to eradicate most of the bacteria. Additionally, clumped bacterial cells on the skin are more difficult to eradicate than single bacterial cells [7]. Micro-organisms can also be found in the deeper layers of the skin and on skin appendages such as sweat glands, sebaceous glands and hair follicles [8]. Resident bacteria cannot be eradicated by disinfection and run the risk of contaminating blood products after venepuncture [9].

2.2 Dimpled Phlebotomy Sites

Dimpled phlebotomy sites tend to make skin disinfection less effective. Repeated blood donations result in scarring of the skin and the formation of dimples at the venepuncture sites. Research has shown that dimpled and scarred phlebotomy sites make disinfection less effective and lead to a higher risk of bacterial contamination of blood products [10].

2.3 Resistance to Disinfection

Bacterial resistance to disinfectants can be innate or acquired [11]. Innate resistance of bacteria to the disinfection process is due to structures that act as barriers. For example, bacterial spores are resistant due to the spore coat and cortex. Gram-negative bacteria are surrounded by an outer membrane and mycobacteria have an outer waxy cell wall which makes the uptake of disinfectant more difficult [7].

Disinfectants are useful in reducing the number of skin flora but over time bacteria are known to develop a degree of resistance to the product [12]. Resistance can be acquired by a mutation or by amplification of an endogenous chromosomal gene [11]. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) tend to be higher in places where disinfectants are routinely used, such as blood establishments and operating theatres [13]. One of the most commonly found bacteria on the antecubital fossa is the Gram-positive *Staphylococcus aureus* and it produces protein complexes known as adherents that will help it adhere to the skin [14]. One of the reasons why *Staphylococcus aureus* has a higher MIC is due to mutations in the *smr* and *norA*, *qacA*, and *qacB* genes [11]. Since the skin contains various bacterial species and strains, those that are resistant to disinfectants will survive the process of disinfection, thus causing the risk of contaminating blood products [13]. The World Health Organization recommends chlorhexidine (CHX) to be used as a skin disinfectant prior to venepuncture and it is one of the most widely used disinfectants in health care settings [15]. When compared to other disinfection products, CHX offers the greatest residual activity which means its antimicrobial effect is maintained even after drying completely [16]. Although 0.5% CHX is effective at eradicating a vast number of Gram-positive and Gram-negative bacteria, it is responsible for the low bacterial reduction rates and for the increasing microbial persistence [17].

2.4 Biofilm Formation

Bacteria have the ability to form a dense layer and attach themselves firmly to the skin surface, thus they are difficult to remove by the disinfection process [7]. The MIC of CHX required to inactivate bacteria in biofilms is 64 times higher than the MIC required to inactive free-floating bacteria. Once formed, bacteria produce a matrix which will further protect them from the action of disinfectants. An example of bacteria which can form biofilms is *Staphylococcus epidermidis* and it is one of the main contaminants of platelet units [18].

2.5 Low Concentrations of Disinfectants

When a disinfectant below the MBC is used, it will likely be ineffective when it comes to eliminating bacteria. Additionally, disinfectants at low concentrations may cause bacteria to exhibit the hormetic effect. This means that bacteria are stimulated to grow even more at low concentrations of a disinfectant [19].

3. THE CLEANING TECHNIQUE

The cleaning technique is divided into 3 stages: preparation, washing and drying [20]. The first stage involves wetting the skin with water before the application of soap. The second stage involves the application of liquid soap to the skin and rubbing for a few seconds to create a lather. This is followed by scrubbing the skin for at least 20 seconds [21]. Friction is created through the action of scrubbing the skin with soap and water on the skin. This helps to lift off bacteria from the skin [4]. Prolonged washing time i.e., more than 30 seconds, loosens resident bacteria from the skin but does not remove them. Therefore, rinsing with clean and running water is essential to remove the loosened resident bacteria by dilution [22]. Drying the skin with a clean towel is an important last stage but many tend to skip it [21]. Drying the skin after cleaning makes it more difficult to acquire bacteria on the skin [23].

The uppermost layer and deeper layers of the skin harbour many resident and transient bacteria [24]. Apart from causing diseases when transmitted from one person to another, they run the risk of contaminating blood products if proper cleaning of the antecubital fossa is not carried out [25]. Cleaning the skin with soap and water is more effective than washing the skin with just water or no hand washing at all [26]. Cleaning the skin with just water is ineffective because bacteria are mixed with the oil on the skin. Oil and water are immiscible; therefore, soap is needed to be able to remove both oil and bacteria from the skin [4].

Soap is a detergent-based product that contains sodium or potassium hydroxide and esterified fatty acids. It also contains surfactant molecules which lower the surface tension between water and oil on the skin, making it easier for surfactant molecules to reach the skin surface and exert their effect. Surfactant molecules in soap can exist in two forms: as monomers when they are low in concentration, but they can also come together to form micelles when they are at a high concentration, also known as the critical micelle concentration. A surfactant monomer is amphipathic as it consists of a hydrophilic head and a lipophilic tail. When they are in the micelle shape, they come together in a way that the lipophilic tails point inwards, and the hydrophilic heads point outwards [27]. Some bacterial cell membranes have a similar structure to that of surfactant monomers. The cell membrane is also amphipathic as it consists of a phospholipid bilayer with an outer hydrophilic region and a middle lipophilic region. Like a micelle, the phospholipid hydrophilic heads in the bacterial cell membrane point outwards and the lipophilic tails point towards the centre. The presence of oil on the skin makes it easier for bacteria to adhere to the skin [28].

3.1 How Cleaning Works

When surfactant monomers come in contact with the skin through the act of cleaning, they insert themselves in the outer half of the bacterial cell membrane and similarly arrange themselves. Surfactant monomers put mechanical stress on the bacterial cell membrane and bend it. Consequently, pores in the bacterial cell membrane form which leads to the breakdown of the bacterial cell. Hybrid micelles form containing both surfactant monomers and phospholipids from the bacterial cell membrane [27].

3.2 Why is Cleaning Necessary?

The presence of dirt on the skin increases the bacterial load, and as mentioned earlier, the bacterial load on the skin affects the effectiveness of disinfection. The higher the bacterial load on the skin, the less effective disinfection will be [6]. Dirt on the skin can act as a barrier which prevents the disinfection product from reaching the surface of the skin and effectively performing it [21]. Since cleaning reduces the initial bacterial load on the skin, it helps to increase the effectiveness of the disinfection process, which will remove the remaining bacteria [29]. Cleaning also makes the disinfection process more effective by perforating the outer membranes of bacteria which will be further broken down during disinfection [4].

Bacteria on the skin can proliferate to colonise the skin surface and produce a biofilm [30]. To increase their adherence to the skin and their proliferating capability, bacteria produce an extracellular matrix containing DNA, lipids, proteins and polysaccharides [31]. Surfactant molecules disrupt the cohesive forces in the extracellular matrix and the bonds between bacteria and the skin, detaching them from the skin [30]. Micelles can also trap the oil on the skin, which makes bacteria more likely to adhere to the skin. During rinsing, hybrid micelles are washed off; therefore, removing bacteria that were once present on the skin [28].

4. CONCLUSION

The presence of bacteria on the skin is one of the main causes of bacterial contamination of blood products. One of the reasons is inadequate skin disinfection before venepuncture. Bacteria may remain present on the skin even if skin disinfection is carried out properly. Cleaning of the skin also reduces the bacterial load through the action of detergent monomers. Therefore, to further reduce the bacterial load on the skin, cleaning of the antecubital fossa should be carried out, making skin disinfection more effective.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Suddock JT, Crookston KP. Transfusion Reactions. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2023 Oct 12]. Available:http://www.ncbi.nlm.nih.gov/books/NBK482202/
2. Wagner SJ, Leiby DA, Roback JD. Existing and Emerging Blood-Borne Pathogens: Impact on the Safety of Blood Transfusion for the Hematology/Oncology Patient. Hematol Oncol Clin North Am. 2019;33 (5):739–48.
3. Vamvakas EC, Blajchman MA. Transfusion-related mortality: the ongoing risks of allogeneic blood transfusion and the available strategies for their prevention. Blood. 2009;113(15):3406–17.
4. Centers for Disease Control and Prevention. Show Me the Science - How to Wash Your Hands [Internet]. 2021 [cited 2023 Oct 12]. Available:https://www.cdc.gov/handwashing/show-me-the-science-handwashing.html
5. Swaney MH, Kalan LR. Living in Your Skin: Microbes, Molecules, and Mechanisms. Infect Immun. 2021;89 (4):e00695-20.
6. Arghittu A, Dettori M, Deriu GM, Soddu S, Manca PC, Carboni AA, et al. Controlling Infectious Risk in Transfusion: Assessing the Effectiveness of Skin Disinfection in Blood Donors. Healthcare (Basel). 2022;10 (5):845.
7. Centers for Disease Control and Prevention. Factors Affecting the Efficacy of Disinfection and Sterilization [Internet]. 2019 [cited 2023 Oct 12]. Available:https://www.cdc.gov/infectioncontrol/guidelines/disinfection/efficacy.html
8. Callewaert C, Ravard Helffer K, Lebaron P. Skin Microbiome and its Interplay with the Environment. Am J Clin Dermatol. 2020;21 (Suppl 1):4–11.
9. Pratt R, Hoffman P, Robb F. The need for skin preparation prior to injection: point — counterpoint. British Journal of Infection Control. 2005;6(4):18–20.
10. McDonald CP. Bacterial risk reduction by improved donor arm disinfection, diversion and bacterial screening. Transfus Med. 2006;16(6):381–96.
11. Rozman U, Pušnik M, Kmetec S, Duh D, Šostar Turk S. Reduced Susceptibility and Increased Resistance of Bacteria against Disinfectants: A Systematic Review. Microorganisms. 2021 ;9(12):2550.
12. Lu J, Guo J. Disinfection spreads antimicrobial resistance. Science. 2021; 371(6528):474–474.
13. van Dijk HFG, Verbrugh HA. Resisting disinfectants. Commun Med. 2022;2(1):1–5.
14. Byrd AL, Belkaid Y, Segre JA. The human skin microbiome. Nat Rev Microbiol. 2018 ;16(3):143–55.
15. World Health Organization. Venepuncture for blood donaton. In: WHO Guidelines on Drawing Blood: Best Practices in Phlebotomy [Internet]. World Health Organization; 2010 [cited 2023 Nov 18]. . Available:https://www.ncbi.nlm.nih.gov/books/NBK138671/
16. Lim KS, Kam PCA. Chlorhexidine--pharmacology and clinical applications.

Anaesth Intensive Care. 2008;36(4):502–12.
17. Celere MS, Ferreira O, Ubiali EMA, Julião FC, Fernandes AFT, de Andrade D, et al. Antimicrobial activity of two techniques for arm skin disinfection of blood donors in Brazil. Transfus Med. 2012;22(2):116–21.
18. Taha M, Kalab M, Yi QL, Landry C, Greco-Stewart V, Brassinga AK, et al. Biofilm-forming skin microflora bacteria are resistant to the bactericidal action of disinfectants used during blood donation. Transfusion. 2014;54(11):2974–82.
19. Morales-Fernández L, Fernández-Crehuet M, Espigares M, Moreno E, Espigares E. Study of the hormetic effect of disinfectants chlorhexidine, povidone iodine and benzalkonium chloride. Eur J Clin Microbiol Infect Dis. 2014;33(1):103–9.
20. Seal K, Cimon K, Argáez C. Hand Antisepsis Procedures: A Review of Guidelines [Internet]. Ottawa (ON): Canadian Agency for Drugs and Technologies in Health; 2017 [cited 2023 Oct 12]. (CADTH Rapid Response Reports).
Available:http://www.ncbi.nlm.nih.gov/books/NBK470488/
21. Centers for Disease Control and Prevention. When and How to Wash Your Hands [Internet]. 2023 [cited 2023 Oct 12].
Available:https://www.cdc.gov/handwashing/when-how-handwashing.html
22. Michaels B, Gangar V, Schultz A, Arenas M, Curiale M, Ayers T, et al. Water temperature as a factor in handwashing efficacy. Food Service Technology. 2002; 2(3):139–49.
23. World Health Organization. Normal bacterial flora on hands. In: WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care Is Safer Care [Internet]. World Health Organization; 2009 [cited 2023 Nov 18].
Available:https://www.ncbi.nlm.nih.gov/books/NBK144001/
24. World Health Organization. Review of preparations used for hand hygiene. In: WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care Is Safer Care [Internet]. World Health Organization; 2009 [cited 2023 Oct 12].
Available:https://www.ncbi.nlm.nih.gov/books/NBK144041/
25. Dubey A, Sonker A, Chaudhary R. Snake in the grass: A case report of transfusion reactions due to contaminated donor arm disinfectant. Asian J Transfus Sci. 2017; 11(1):50–2.
26. Burton M, Cobb E, Donachie P, Judah G, Curtis V, Schmidt WP. The effect of handwashing with water or soap on bacterial contamination of hands. Int J Environ Res Public Health. 2011 ;8(1):97–104.
27. Woods Z. LifeCanvas Technologies. 2020 [cited 2023 Nov 17]. How do detergents dissolve lipid membranes?
Available:https://lifecanvastech.com/how-do-detergents-dissolve-lipid-membranes/
28. National Institute of Health. National Institutes of Health (NIH). 2009 [cited 2023 Nov 17]. Study Finds Unexpected Bacterial Diversity on Human Skin.
Available:https://www.nih.gov/news-events/news-releases/study-finds-unexpected-bacterial-diversity-human-skin
29. US. Department of Agriculture. Clean THEN Sanitize: A One-Two Punch to Stop Foodborne Illness in the Kitchen [Internet]. 2019 [cited 2023 Nov 17].
Available:https://www.usda.gov/media/blog/2019/08/27/clean-then-sanitize-one-two-punch-stop-foodborne-illness-kitchen
30. Falk NA. Surfactants as Antimicrobials: A Brief Overview of Microbial Interfacial Chemistry and Surfactant Antimicrobial Activity. J Surfactants Deterg. 2019;22 (5):1119–27.
31. Brandwein M, Steinberg D, Meshner S. Microbial biofilms and the human skin microbiome. NPJ Biofilms Microbiomes. 2016;2:3.

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