Mini Review

Blood Donor Arm Disinfection – Preventing the Contamination of Blood Components

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Abstract

Blood Donor arm disinfection is an essential step to minimize the possibility of blood products becoming contaminated making them unsafe for transfusion therapy. Contamination of blood by microorganisms may lead to a transfusion sepsis with consequences which range from mild to fatal. Several different disinfection procedures have been suggested in literature and aim to reduce the occurrence of contamination from skin commensals during venepuncture. Such procedures vary from each other in the number of different application steps and the variety of different disinfectants used. Consistent, efficient disinfection is always a priority and therefore, having a well-established and effective procedure will help in achieving this.

Keywords: blood donor, disinfection, contamination, blood products

Introduction

The human skin is a host to a variety of microorganisms. Their presence varies on different skin sites according to the conditions that favour the proliferations of certain species over others. The scope of disinfection is to prevent infection from occurring when there is a breach in the skin barrier, such as in the case of medical procedures [1]. In the context of a blood donation, skin disinfection is done to avoid introducing potential pathogens in the donated blood. Indeed, circulating blood is normally devoid from microorganisms [2]. Sepsis is one of the many risks associated with a blood transfusion and can easily become fatal if not treated rapidly. The symptoms of sepsis may be easily confused with other adverse transfusion reactions, making it hard to distinguish such cases upon first onset. Such symptoms include a high fever, chills, hypotension, nausea and tachycardia [3], followed by septic shock, renal failure and disseminated intravascular coagulation and finally death if the patient in not treated urgently [3]. Sepsis due to contaminated blood products is a very rare occurrence within transfusion recipients that have a robust immune system. However, this is not the case for immunocompromised patients, most notably transplant or chemotherapy recipients. This cohort presents at a much higher risk for fatal transfusion infections due to their weakened immune system [4]. Gram-negative bacteria are a particularly dangerous blood product contaminant as sepsis caused by these organisms have a rapid onset due to the production of endotoxins [5]. The release of endotoxins stimulates the erratic release of cytokines by the transfusion recipient resulting in septic shock. Severity of sepsis is determined by the amount of contaminated blood product transfused and the concentration of contaminant present within said product. This amount can vary depending on the number of days passed after blood donation. The older the blood product, the higher concentration of bacteria [6].
Blood Products and Contamination

The antecubital fossa, the site of venepuncture for a blood donation, is particularly humid. Here one will predominantly find Proteobacteria and Staphylococci bacteria [7]. Sepsis is more commonly a result of the transfusion of contaminated Platelets Concentrates (PCs) rather than Red Cell Concentrates (RCCs). This is because cold storage conditions restrict the ability of growth for a large subset of bacteria [8]. Most bacteria implicated in contamination of blood products are facultative anaerobes and some organisms such as Yersinia enterocolitica, are known to grow in refrigerated RCCs as they possess yersiniabactin siderophores which allow sequestration of iron [9]. This organism usually originates from donors with transient bacteraemia at the time of collection. Other organisms that show viability within RCCs during storage include those belonging to the genus of Serratia and Pseudomonas [5]. In a study conducted by Illert et al. [10] whole blood was shown to have the smallest rate of bacterial contamination when compared to culture results obtained from processed blood products. This highlights the importance why donated blood should not be processed immediately after collection. During this standing time, leukocytes within the whole blood attack the microbes present reducing their number. In the case of blood components leucocytes are removed by filtration which will allow for an easier proliferation if bacteria are still present. However, care must be taken not to delay processing for extended periods of time to avoid the loss of 2,3-diphosphoglycerate, which is essential for red cells to carry oxygen [11]. Although fresh frozen plasma is stored at very low temperatures, contaminated bacteria will not be neutralised and may still pose a threat to the recipient.

Other Contaminants

Bacteria, albeit the most common blood product contaminant, is not the only type of organism that inhabits the skin. Fungi also coexist as part of the skin microbiota and these too have a potential to contaminate blood products and cause infection. Instances of transfusion related infection due to fungal organisms is a rare event and few cases are reported in literature. Just like bacteria, different species and genera of fungi also possess different degrees of resistance to disinfectants. Fungal infections mainly occur in immunocompromised patients and are predominantly caused by Candida albicans, Cryptococcus neoformans and Aspergillus fumigatus [12]. Candidiasis can proliferate mainly in patients undergoing chemotherapy or due to prolonged antibiotic use [13]. Unfortunately, fungal sepsis carries a higher risk of mortality when compared to bacterial sepsis [14]. In healthy individuals the likelihood of infection is very low due to the highly effective defence mounted by the complement system. Individuals lacking the CCL5 chemokine as well as having neutropenia as a result of chemotherapy treatment, have been shown to be highly susceptible to such infection [15].

Preventing Bacterial Contamination of Blood Products

Limiting the exposure of the donated blood to any contaminants is a priority for any Blood Establishment. Disinfection of the antecubital fossa remains the most important step in preventing contamination. The most common strategy to prevent such contamination is that of disinfecting the skin prior to blood collection. This procedure involves the application of a disinfectant containing solution that can eliminate most of the microorganisms present on the antecubital fossa.

Disinfectants

One of the earliest known use of skin disinfectant was done by the ancient Egyptians, were vinegar was used to cleanse corpses and aid their preservation during the process of embalming [16]. The most successful implementation of disinfectant use in the history of medicine dates to 1847, where Dr Ignaz Semmelweis pioneered hand washing using chlorinated lime by doctors and staff in maternity wards. This resulted in a significant reduction in mortality caused by puerperal sepsis in newborns [17]. A good disinfectant should not only act on the stratum corneum which is the
keratinised superficial layer of the skin [18]. This is because certain bacteria especially commensals, house themselves in between deeper skin cell layers [19]. When venepuncture is performed, skin fragments or a single whole skin plug is produced. These can carry the bacteria that are lodged deep within the skin when disinfection is not effective [20]. Disinfection is further hindered by the presence of skin scars or skin conditions at the venepuncture site. Such occurrence can increase the chance of disinfection failure as scars create hard to reach pockets where bacteria can reside [21]. Many different chemical solutions can be applied for disinfection, yet nowadays a few of them are available and are both effective and safe for use on human skin. A good disinfectant must satisfy different criteria as set by the Blood Donation Service. Such a disinfectant must be able to act on microorganisms as soon as it is applied on the skin. It should have optimal bactericidal activity rather than bacteriostatic properties, meaning it must kill and not just temporarily inhibit growth [22]. Another desired property is that the disinfectant should not have any side effects on the skin of the Donor skin, meaning it must not cause rashes, itchiness or any other adverse reactions, as this may deter people from donating again [23].

The blood diversion pouch and leukofiltration

Apart from skin disinfection, blood diversion is another step implemented during blood donation to minimise bacterial contamination. This involves the collection of the first few milliliters of blood drawn, to trap the skin plug and prevent its entry into the mother bag. This is important since skin disinfection does not mean that the site is sterile [24]. Another important step in ensuring safety of the donated blood is leukofiltration. This simple procedure involves the passing of the blood product via a filter after blood component separation.

Pathogen Reduction

Contamination may also be reduced by the implementation of pathogen reduction techniques. Such techniques combine the use of ultraviolet light and substances such as psoralen to target nucleic acids present within the DNA of pathogens that might be present within RCCs and PCs. This eliminates them whilst doing the least harm as possible to the normal cells and other constituents of the blood product [25]. Unfortunately, pathogen reduction does not guarantee elimination of all pathogens [26].

Arm disinfection troubleshooting

When looking at various disinfecting regimens, there is no universal consensus on the type of disinfectant that should be used. The most common mentioned are Chlorhexidine (CHX) and Povidone Iodine [27]. Concentrations for both disinfectants mentioned and the formulations in which they are used also vary from one donation service to another. It has been reported that CHX is commonly used at a concentration varying from 0.5% to around 2% for blood donor arm disinfection [28,29]. Some argue that Povidone Iodine is more effective at bacterial reduction [30-32], while other studies concluded that CHX provided additional benefits [33,34]. Another issue of concern is that the amount of disinfectant applied to the arm is not standardised. Variations in the amount of disinfectant being applied to the cubital fossa of one donor to another may lead to different degrees of success with regards to disinfection. One way to mitigate this is to use prefabricated applicators rather than manually adding the disinfectant to a sterile gauze [27]. This ensures that the same amount of disinfectant is applied on the skin of every donor. The main disadvantage with the use of applicators and pre-wetted gauzes is that the price is significantly higher than when just using bulk solution. Yet eventually the change can be cost effective in the long run, if the amount of contaminated blood products is significantly reduced since less blood products are thrown away and sepsis can be quite costly to treat. External factors also contribute to the success of disinfection. The work environment of the donor and during which season the donation occurred seemed to affect the efficacy of disinfection according to a study by Cid et al. [35]. In their study they noted that Blood Donors who worked outdoors during the summer had a lower bacterial reduction when compared to other test groups. This was attributed to worse hygiene as well as the possibility that sweat plays a key role in maintaining
skin. Soap can be used before the application of disinfectant to clean the venepuncture site from any visible dirt or grime which can carry pathogens derived from the environment. Dirt can carry bacterial spores that are highly resilient to the action of disinfectants, so the removal of dirt by means of soap and water may be required if present in excess. The use of soap will further help reduce the risk of contamination [36], however it is to be noted that not all soaps may have the same bactericidal effect [37].

Different forms of alcohol are probably some of the oldest and most extensively used disinfectants. The bactericidal mechanism of alcohol is linked to the ability of alcohol to denature protein in the presence of water [38]. This explains the preference of using alcohol concentrations between 70-80% for medical applications. Additives can also be supplemented to the alcohol solution to reduce its rate of evaporation thus increasing its contact with the skin [39]. In a study performed by Taha et al. [40], alcohol disinfection was found to be less effective at the subsurface of the skin and failed to eliminate certain organism, most notably *Staphylococcus epidermidis*, a skin commensal, and *Staphylococcus aureus*, a potential pathogen. This is further supported by a study conducted by Luther et al. [41], who conclude that *Staphylococcus epidermidis* behaved similarly to *Staphylococcus aureus* when it came to biofilms. These biofilms shield the organisms from the disinfection action, allowing them to maintain their viability in the collected blood [42]. Different types of alcohol such as ethanol, methanol, isopropanol, isoamyl alcohol and n-butanol performed similarly in terms of disinfection efficacy [43]. However, high concentrations of alcohol of up to 100% were also found to instigate the production of biofilms [41]. This outcome may be due to the activation and expression of *mmpL, vraS*, and *mepA* genes, which also confer drug resistance in *Staphylococcus aureus* [43].

One of the most common disinfectants used is CHX with the addition of alcohol. Its popularity is attributed to the low incidence of adverse reactions [44], broad-spectrum antimicrobial activity [42] and its ability to linger on the skin [45]. CHX forms part of the biguanides family of compounds, all of which are known to have bactericidal activity. They act on bacterial cells by destroying the structure of their membrane facilitated by rapid absorption through the cell wall, followed by the loss of key cellular function by the precipitation of nucleic acids and proteins [42]. Biguanides are most effective in neutralising Gram-positive organisms, but are less effective against certain Gram-negative organisms, fungi, viruses and are unable to destroy spores [42]. Mycobacteria are exceptionally resistant to CHX due to their unique cell wall structure that reduces its absorption and prevents it from reaching the membrane [46]. CHX is therefore commonly used in conjunction with other disinfectants (such as alcohol) to increase its efficacy. Upon evaporation of the alcohol, the CHX becomes more concentrated and deposits on the surface of the skin, prolonging its antimicrobial activity [23]. The main issue when it comes to its safety is the potential toxicity of CHX [44]. Once the alcohol evaporates the compound will persist on the skin and may thus be absorbed inside the body. However, there is little concern when it comes to its use as a disinfection agent as only a small amount and concentration is applied.

Disinfection of the antecubital remains the most important step in preventing bacterial contamination. The disinfection procedure should be regularly audited to verify its efficacy. Such monitoring should involve taking sample swabs both before and after the application of the disinfectant from the antecubital fossa area. Swabbing needs to be done on a non-selective medium which facilitates the growth of multiple organisms. A log reduction of the bacteria cultured before and after disinfection can be then calculated and this is then compared with the target reduction as directed by the Quality Assurance of the Centre. Healthcare professionals involved in the process of blood donation may also be sampled to determine if hand hygiene is maintained according to the protocols set for hand washing and disinfection. This is to ensure that aseptic technique is maintained throughout the process of blood donation and to minimise the transfer of organisms from the Phlebotomist to the disinfected area prior to venepuncture [47].
Conclusion

Nowadays, the incidence of transfusion related infections has decreased drastically thanks to the use of aseptic technique, closed systems during blood collection, active screening for viral infections and good disinfection techniques. Contaminant-free blood products are essential for the wellbeing of patients requiring transfusion. This can be achieved using different methods, but just the simple act of proper donor arm disinfection plays a large part in ensuring safety of such products. Regular evaluation is therefore required to ensure that the procedure of donor disinfection currently in use is effective. If proper arm disinfection is not achieved, changes must be made quickly to prevent morbidity and mortality as a result of transfusion-related bacterial infections. These can include altering the disinfectants used in the cleaning solution, by opting to change physical aspects of the procedure or by introducing pathogen reduction measures. In addition, the way forward is to develop new strategies that allow the detection of microorganisms within a relative shorter time period.

References


