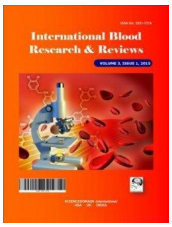

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Bacterial Contamination of Blood and Blood Components: Reducing the Risks in Nigeria

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Authors' contributions

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

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ABSTRACT

Introduction: Administration of blood and blood products is very life-saving. However, the safety of blood transfusion in resource-limited nations is questionable unlike in many developed nations of the world. The risk of viral transmission has been significantly curtailed, but bacterial transmission and infection continue to be a significant challenge in transfusion medicine. Bacterial screening is not usually carried out on platelets and other components of blood in Nigeria except on rare occasions after transfusion reaction due to bacterial contamination is highly suspected.
Aims: To discuss the risk of bacterial contamination of blood components in a resource-limited setting like Nigeria and measures that can be instituted to reduce it.
Results: the sources and risks of bacterial blood contamination in Nigeria were reviewed and discussed as well as steps that can be taken to limit such.
Conclusion: Bacterial screening of blood and blood components prior to administration is rarely done in Nigeria and since the donor's arm is the primary potential source of contamination, efforts should be made to have a pool of altruistic non-remunerated blood donor to limit the risk.

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1. INTRODUCTION

Blood for transfusion is a potential source of infection by a variety of known and unknown transmissible agents [1]. Bacterial infection of blood components remains a significant problem in transfusion medicine and is undoubtedly associated with high morbidity and mortality everywhere in the world, though improved blood collection practices, refrigeration of red cells, freezing of plasma, and improved materials for transfusion product collection and storage have partly reduced the incidence. Approximately, 30 million units of blood component are transfused yearly in the USA, and bacterial contamination of platelet concentrate is the most frequent infectious risk from transfusion occurring in approximately 1 of 2,000–3,000 whole-blood derived, random donor platelets, and apheresis-derived, single donor platelets. After clerical errors, bacterial contamination is the second most common cause of death overall from transfusion. Death rates from platelet-associated sepsis range from 1:20,000 to 1: 85,000 donor exposures [2-6]. According to the only survey ever conducted(2005), approximately 1.5 million units of blood is required yearly. This perhaps could be an underestimation in a country of about 180 million people [7]. Various studies from different parts of Nigeria have estimated the prevalence and risks of viral transmission [8-11]. However; data are unavailable on the prevalence and risks of bacteria transmission via blood components transfusion in Nigeria. Bacteria species are uniquely different from viruses because the blood serves as a proper milieu for their growth and proliferation during storage. Also, unlike other components which are stored at lower temperature, platelet storage ($22^{\circ}c \pm 2^{\circ}c$) favours bacterial growth. Arguably, bacterial contamination of whole blood and its various components can occur at several points including the production of blood bags, donor venepuncture, blood donor bacteraemia, blood component separation or at the time of transfusion.

The sources of bacterial contamination in the blood cannot always be easily traced due to the presence of bacteria in our surroundings. In contrast to viruses that required target cells for replication, bacteria require oxygen, nutrients, water, adequate temperature and pH to proliferate. Platelet products are the most susceptible to bacterial contamination due to their storage conditions at 20-24°C in oxygen permeable bags. The anticoagulant solution provides glucose and normal pH environment for bacterial growth. Bacterial-related transfusion infection, though usually not reported has been a growing concern for many clinicians and other health workers in Nigeria. In our clinical transfusion practice, there have been cases of suspected bacterial infection that were never diagnosed due to inadequate resources and lack of diagnostic tools. In summary, the bacterial contamination of blood components is still a challenge in transfusion medicine and is essential for all blood components [12]. Considerable efforts (and national policies) directed towards reducing transmissible pathogens (improved donor selection and newer screening techniques) have yielded a significant reduction of these agents in advanced countries

This article aims to describe the various stages of possible bacterial contamination from donation to issuing of blood and discuss the risks of transfusion-associated bacterial infection. We hope this will serve as a wake-up call for health professionals in Nigeria, directly or indirectly involved in transfusion medicine to observe adequate safety measures to limit contamination.

2. METHODS

Online searches on the following databases such as Google Scholar, PubMed, and Biomed Central, were done. An attempt was made to review articles with keywords such as blood transfusion, blood safety, and bacterial contamination of blood.

2.1 Blood Transfusion Risk in Nigeria

The safest source of blood is voluntary non-remunerated donors. The risk of blood transfusion in Nigeria is enormous. The safety of blood in Nigeria continues to be a growing concern mainly because commercial donors are responsible for up to 90% of blood supply while voluntary and family replacement donors contribute only about 10% [13]. Socio-demographic studies of blood donors in Nigeria identified a male-dominated donor pool as well as young adults as the dominant donor age group which reflect the active age and gender stratum of the Nigerian population [9,10]. However, probably due to involvement in high-

risk behaviours, this age group has also been associated with the highest carriage rates of transfusion-transmissible viral infections. [11] Most bacterial species can proliferate in the nutrient-rich blood environment upon storage. Compared to other blood components, platelets have a higher risk of being contaminated. The level of contamination at the time of blood collection is thought to be relatively low (1–10 colony forming units/mL or less) [14]. Once the product is contaminated, the inoculated bacterial can proliferate over few hours to reach levels of 10^6/mL or greater [2]. Transfusion of blood products with such quantities of bacteria over a short period of time can cause bacteraemia that may potentially progress to sepsis and death. The outcome will be highly dependent on the number of bacteria transfused, the species of bacteria and its pathogenicity for humans, the rate of transfusion, and the clinical status of the recipient [2]. The sources of component bacterial contamination which can lead to fatal infection can occur at various stages from donation, processing, storing and issuing.

Little or no attention has been given to the risk of bacterial contamination of blood and blood components in Nigeria and other Africa countries [15-17]. There is a scarcity of data on studies relating to the prevalence of bacterial contamination of blood in our setting. A survey carried out in Southwestern region of the country revealed a prevalence of 8.8% comparable to findings in a few other African countries [15]. Only Gram-positive organisms (*Staphylococcus aureus, Coagulase-negative staphylococci, Bacillus* and *Listeria spp*) were isolated in the study and are thought to have occurred during venesection due to insufficient disinfection of the skin [15]. The finding indicates that the risk of bacterial infection following blood transfusion in Nigeria and other West Africa countries is high compared to the advances nations like USA and UK.

2.2 Sources of Bacterial Contamination of Blood Components

Potential sources of contamination of blood products include asymptomatic donor bacteraemia, contamination of donor skin, contamination of blood collection packs and during blood processing.

Asymptomatic donor bacteraemia: Some donors with asymptomatic bacteraemia with may donate during incubation or recovery period from bacterial illness while others may have a chronic low-grade infection. A case of *Salmonella enterica* from a donor with a low-grade infection of the tibia resulted in seven cases of sepsis, two of which were deadly [18]. Transient bacteraemia following a tooth extraction or even brushing has been reported in some donors implicating *Staphylococcus aureus* [19]. A systemic review of 55 cases of ***Yersinia enterolytica*** revealed that most implicated donors had clinical, bacteriological and serological evidence of recent or on-going gastroenteritis at donation [20].

Skin contamination: It is the most frequent source of contamination of platelet component [19]. Some bacteria which are normal skin flora can become dangerous species to blood recipients, even after proper cleaning [21]. During phlebotomy, a portion of the deep layer of the skin containing bacteria may be inoculated into the blood bag. Common skin floral are coagulase-negative *Staphylococcus, Propionibacteria and Corynebacteria* [22,23].

Contamination of collection pack: leaking blood bags is a potential route of entry for microbes. Heavy contamination of an exterior portion of intact blood bags by *Serratia marcescens* during manufacturing of blood bags have been reported [24,25]. Blood packs may also be contaminated even in the absence of defects.

During blood processing: an open system poses a risk of contamination of blood units at any stage of blood processing. One of the critical stages of the processing is when the bags are placed under pressure from centrifugation; this may increase the size of the small pores in the bag make the bag more susceptible to the entry of bacteria. Poorly hygienic environment and contaminated water baths have also been sources of blood product contamination, especially with *Burkholderia cepacia* and *P. aeruginosa ref.*

2.3 Clinical Features of Transfusion-transmitted Sepsis

It is not all contaminated blood components that cause symptoms in the recipient. The transfusion of an infected cellular blood product unit may be associated with variable signs and symptoms. The early symptoms, when present, are fever and chills, which usually start within 2 hours of commencing blood transfusion. This may progress rapidly to nausea, vomiting diarrhoea, hypotension, oliguria, and endotoxic shock.

Respiratory symptoms: dyspnea, wheezing, and a cough, and bleeding secondary to disseminated intravascular coagulopathy. From studies conducted, it was observed that majority of septic transfusion reactions associated with contaminated red cell components usually occur with units that are more than three weeks old [15], whereas septic reactions associated with contaminated platelets occur generally with units that have been stored for 3 days or more [18]. The factors that determine the clinical severity of transfusion-transmitted sepsis are the bacterial species present in the blood component (Gram-negative organisms cause more toxic reactions, due to the release of endotoxins) bacterial load present in the blood product transfused to a patient and the rate of propagation of the bacteria present . Others factors include recipient factor, such as immunological status, premorbid state (ambiguous, can elaborate) and whether or not the patient is on antibiotics therapy. Attention should be paid to the vital signs of the patients under anaesthesia during blood transfusion as symptoms may be obscured and probably cause a delay in diagnosis.

2.4 Reducing the Risk

The first step toward reducing the risk of transfusion-transmitted infection is improving voluntary non-remunerated blood donation practice among the population through public enlightenment and advocacy. With only about 5% of voluntary donors in Nigeria, [13] it is evident that the people are yet to accept the importance of blood donation as a social norm. The donation of blood by voluntary altruistic non-remunerated donors is indisputably essential for a nation to be able to provide safe blood in adequate quantity for her citizens. Systems based on family replacement donation cannot thrive and will never able to meet clinical demands for blood while paid "donation" poses severe threats to the health and safety of the recipients as well as the donors themselves. The government should make a re-commitment to the National blood transfusion policy established in December 2006 [7] because it is a prerequisite for the achievement of 100% voluntary blood donation declared in Melbourne by the World Health Organisation (WHO) working group in 2009 [26]. Blood transfusion must be recognized as an integral part of the health care system, and the infrastructure, human and financial resources needed to ensure the availability of sufficient supplies of safe blood and blood products are to be provided.

In many resourceful countries, a variety of strategies have been implemented in recent years in an attempt to reduce the residual risk associated with transfusion-associated bacterial infections. These measures include careful donor selection through an improved questionnaire, improved skin disinfection and donor screening, optimising blood component processing and storage; and implementing tests and procedures that can be used to detect the presence of bacteria in blood product units [27,28]. Blood donors should be carefully recruited and counselled with the assurance of their health and safety. Counselling helps in maintaining a pool of safe and healthy voluntary donors thus contributing to blood safety [29]. It helps to minimise wastages of blood, staff and donor time as well as consumables by preventing donations from unsuitable donors [30]. Besides, donor questionnaires should be extended to include questions on diarrhoea, abscesses, osteomyelitis and dental treatment as possible risk factors for asymptomatic bacteraemia [31].

Since the primary source of bacterial contamination is the donor arm, improving donor arm disinfection before puncture is important [32,33]. Enhanced donor arm cleansing using 70% isopropyl alcohol, 2% chlorhexidine gluconate applied as a single-step procedure was recommended by the National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England [28]. The practice of this procedure and adherence to the principle of the specified skin-cleansing system was regularly audited by a periodic bacterial sampling of the donor's arm. This indicated how well staff are complying with the use of the system. This procedures can be embraced and implemented in our setting as it is not relatively cheap and not labour intensive but only require dedication to proper medical and laboratory practice. Since bacteria such as *Propionibacterium* reside in the deep skin area of the arm which may not be adequately cleaned by the fluid, diversion of the first 20–30 mls into a side-arm pouch after blood puncture has been recommended to further reduce the risk of bacterial contamination of blood and blood products [34,35]. Studies convincingly confirmed a reduction in the risk of bacterial contamination by approximately 50% when the procedure is being implemented [35].

Bacteria can contaminate all the blood products, however, platelet concentrate or component, with storage temperature between 20°C to 24°C, is far

more associated with a high-risk of sepsis and related fatality than other transfusible products. [36] Furthermore, the risk of contamination of platelets is influenced by the method of production; platelets produced from single donor or apheresis has the lower risk of contamination compared to platelet sourced from pools [32]. Therefore, bacteria testing of platelet using different automated diagnostic and strategies have been implemented in different parts of the world. This could also be replicated and introduced into our blood transfusion services primarily at the regional blood transfusion centres which will supply the hospital blood banks within the same region. The ideal testing method should be sensitive, specific, easy to operate, rapid and cost-effective. However, no screening method possesses all of these qualities. There are culture techniques (e.g. Haemonetics, BacT/ALERT, Bactec) and rapid assay methods (Real-time PCR, Flow cytometry) [37,38,39,40]. The choice of which method to choose will include sensitivity, specificity and method of operation, although none of this screening methods has all the qualities [41,42]. A medium to high throughput equipment will permit screening of a considerable number of samples at once and thus be cost-effective. Ability to detect a broad spectrum of both aerobic and anaerobic bacteria will also be valuable. Bacterial screening has enabled the extension of shelve life of platelet from 5 to 7 days in the centre around the world where this procedure is being implemented [37,38]. Approximately 14 million units of blood is red cell concentrate is transfused yearly in the United states [1,43]. Notwithstanding, sepsis is a rare phenomenon in the country. The incidence of fatal events from was 1 in 8,000,000,000 and the deaths reported were mostly due to *Yersinia spp*. [12,44] Bacterial culture of whole blood or red cells in most studies commonly yielded gram positive *Staphylococcus and propionebacterium spp.* [1,45,46,47]. The organisms are present on the skin as commensals and can poorly proliferate at the storage temperature of the blood (1°C-6°C). [48] An improvement in hygienic conditions through thorough and effective cleaning of donor hands is crucial in order to minimize bacterial contamination and ensure patient safety.

3. CONCLUSION

Bacterial screening of components of blood in Nigeria is a rare event except when transfusion reaction due to bacterial contamination is highly suspected. Since the primary source of contamination is the donor arm, therefore to reduce the risk of transmission of infection, efforts should be directed towards increasing the recruitment of altruistic, non-remunerated blood donors. The government should also appropriately fund and rejuvenate the National blood transfusion centres in the country.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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