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Pathogenicity of Bacteria Contaminating Blood Products

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Keywords
Bacteria · Contaminations · Pathogenicity

Summary
Bacterial contaminations of blood products often originate from the flora of the donor. Normally, components of the skin flora less frequently give rise to severe or complicated infections, although their participation in such conditions has been described. In contrast, bacteria that can cause infections in immunocompetent persons may give rise to life-threatening infections when present in blood products. The latter microorganisms are well-equipped with a variety of virulence factors that contribute to their pathogenicity.

Schlüsselwörter
Bakterien · Kontamination · Pathogenität

Zusammenfassung
Bakterielle Kontaminationen von Blutprodukten nehmen oft ihren Ursprung in der Flora des Spenders. Dabei führen normale Bestandteile der Hautflora weniger häufig zu schweren oder komplizierten Infektionen, obwohl sie durchaus an solchen Zuständen beteiligt sein können. Im Gegensatz dazu können Bakterien, die schon Infektionen bei immunkompetenten Personen verursachen, zu lebensbedrohlichen Infektionen führen. Diese Mikroorganismen besitzen eine umfangreiche Ausstattung mit Virulenzfaktoren, die zu ihrer Pathogenität beitragen.

Introduction

In a German hemovigilance study 153 suspected cases of transfusion-related blood stream infections were seen between 1997 and 2007 [1]. Of these, 71 were confirmed by laboratory data and 9 had a fatal outcome. Not unexpectedly, the majority of contaminating bacteria belonged to the staphylococci (36) with coagulase-negative staphylococci (CoNS, 26) as the leading species group. In total, a large number of other species, comprising Gram-positive and Gram-negative organisms, were seen. Fatalities were caused by *Staphylococcus aureus*, *Streptococcus pyogenes* and *Enterobacteriaceae*, well in keeping with everyday clinical observations. When platelet concentrates were cultured, the prevalence of contaminants from skin was higher, and CoNS, propionibacteria (mostly *Propionibacterium acnes*) and anaerobic cocci (*Peptostreptococcus* spp.) were the most frequent species [2]. In surveillance cultures of blood products, these bacteria often grow very slowly, precluding their detection before the product is administered [3]. Symptomatic infections with these species, however, are rare; they are most often found as contaminants in clinical samples. Different pathogenicity of isolated species is reflected by different equipment with virulence traits.

Virulence Factors in Gram-Positive Bacteria

Of the commonly encountered Gram-positive microorganisms S. *aureus* and *S. pyogenes* exhibit the highest pathogenicity, which is reflected by their ability to cause disease even in immunocompetent patients. These species may express a number of surface factors that interact with human

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tissue as well as toxins that are responsible for symptoms like toxic shock (the toxic shock syndrome toxin (TSST) of *S. aureus* or the streptococcal pyrogenic exotoxin (SPE) of *S. pyogenes*) [4] or severe pneumonia (the Panton-Valentine leukocidin (PVL) of *S. aureus*). In addition, some of the virulence factors serve to evade the innate immune system of the host [5]. Taken together, these traits unequivocally make *S. aureus* and *S. pyogenes* pathogens that may cause a number of clinical infections such as septicemia, endocarditis and skin infections that may be life-threatening. It is fully comprehensible that contamination of blood products may have detrimental effects if administered to patients.

In contrast, oral or 'viridans' streptococci as well as CoNS are the major constituents of the physiological flora and are often found in clinical samples albeit mostly as contaminants. Nevertheless, severe infections due to these bacteria have been described [6]. Oral streptococci are one of the major causes of infectious endocarditis, and CoNS may not only cause endocarditis but are the main cause of infections associated with implanted devices. Many of the CoNS may form biofilms on solid surfaces. These growth forms are known to be less susceptible to antibiotics and may withstand attacks of the immune system [6]. One species of the CoNS, *Staphylococcus lugdunensis*, is more similar in its pathogenesis to *S. aureus* than to other CoNS [7]. *S. lugdunensis* may cause severe endocarditis, which mimics that caused by *S. aureus* in its clinical course, and also causes abscesses and empyema. Knowledge of its virulence factors is scarce, but it is known to express a fibrinogen-binding protein, which may act as a virulence factor during endocarditis and wound infections, and a family of hemolysins called SLUSH (*S. lugdunensis* synergistic hemolysin). In contrast to *Staphylococcus epidermidis*, *S. lugdunensis* is commonly encountered in the lower extremities of the body [8]; thus its prevalence in blood samples is lower than that of *S. epidermidis*.

Other skin commensals such as *P. acnes* or *Peptostreptococcus* spp. are frequently encountered in blood products [2] although *P. acnes* proliferates slowly if at all in drawn blood or platelet concentrates and is often not detected before the product is administered [1, 3]. Although *P. acnes* is most often a skin contaminant, even if cultured from clinical samples, severe infections such as endocarditis or spondylodiscitis [9] have been described [10]. In addition, it has been hypothesized that *P. acnes* contributes to the development of prostate cancer [11].

Peptococci and peptostreptococci are strictly anaerobic Gram-positive cocci which also inhabit the skin. Similar to propionibacteria they are only rarely of clinical significance although infections such as spondilitis [12] or liver abscesses have been described [13].

Even obligat aerobic Gram-positive rods such as *Bacillus* spp. and *Paenibacillus* spp. that are very often contaminants may cause severe infections at least when injected intravenously, e.g., in drug addicts [14–16].

Virulence Factors in Gram-Negative Bacteria

Gram-negative rods such as the *Enterobacteriaceae* are well known for their ability to cause life threatening infections. Although they do not normally colonize the skin of the forearm, they may be present transiently and may even cause asymptomatic bacteremia [17, 18]. At least *Klebsiella* is able to grow in drawn blood [19, 20] and therefore may reach high bacterial counts in the blood product. *Yersinia*, *Klebsiella*, *Escherichia coli*, *Salmonella*, *Serratia*, and other *Enterobacteriaceae* possess a plethora of virulence factors such as toxins, adhesins, iron scavenging mechanisms and capsules that may enable them to cope with host defense mechanisms [21, 22]. In addition all of them express lipopolysaccharides, which, through its common component lipid A, promote development of shock symptoms [23]. These properties make enterobacteria the most frightening contaminants of blood products. Especially contaminations by *Klebsiella pneumoniae* often lead to fatal outcomes [24].

Conclusions

From clinical observations as well as from our knowledge about the virulence traits harbored by *Enterobacteriaceae*, *S. aureus*, *S. lugdunensis* and *S. pyogenes,* it is evident that these species are the most undesirable contaminants in blood products. Often, but not always, these species grow fast enough to allow detection by blood cultures before a platelet concentrate is given to a patient. In contrast, skin commensals such *P. acnes* grow slowly if at all in blood products and rarely lead to severe transfusion-related side effects. Although for absolute safety detection of even minute contaminations including slow-growing species is needed, present means of detection offer sufficient sensitivity for the most pathogenic species.

Disclosure Statement

The author declared no conflict of interest.

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