



Bacterial infections of the folds (intertriginous areas)

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Abstract The axillary, inguinal, post-auricular, and inframammary areas are considered skin folds, where one skin layer touches another. Skin fold areas have a high moisture level and elevated temperature, both of which increase the possibility of microorganism overgrowth. A massive amount of bacteria live on the surface of the skin. Some are purely commensal; thus, only their overgrowth can cause infections, most of which are minor. In some cases, colonization of pathogenic bacteria causes more serious infections. This contribution reviews the bacterial infections of the skin fold areas.

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Introduction

The resident microorganisms of the surface of the skin and hair follicles may increase in number and cause minor infections; nevertheless, pathogenic bacteria that are not normally found on the surface of epidermis can potentially cause serious infections.¹ On some occasions, bacteria colonize on the surface of the skin in large amounts and over long periods of time. These bacteria are called temporary residents of the skin surface. As an example of this condition, skin of the facial area may be contaminated through the nostrils or mouth by *Staphylococcus aureus* or β -hemolytic streptococci, even though these organisms are not members of normal resident flora.² Similarly, if the skin is damaged or an immunosuppressive condition exists,

bacteria that are usually regarded as nonpathogenic can also cause opportunistic infections.

From the viewpoint of host defense mechanisms, the nature and health of the epithelia, the ability of cells to replicate, the interactions between normal floral microorganisms and pathogens, and the cellular and humoral immune factors (eg, diabetes mellitus, HIV infection) are important in maintaining self-protection against microorganisms. Compared with the normal skin surfaces, skin fold areas, such as the axillary and inguinal regions, areas behind the external ear, and inframammary areas have relatively thinner epithelia. The effects of elevated temperature and increased moisture can be seen in these areas. Low levels of oxygen combined with high levels of humidity and elevated temperatures make these areas more prone to microorganism overgrowth.

The pH of the skin surface also plays a role in determining the microbial inhabitants. It is usually acidic and is so named

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the acid mantle. The pH value varies and is higher in the intertriginous areas, such as the axillae and groin.³

Normal flora of the skin

Numerous methods can be used to obtain samples from normal or infected skin. The best quantitative method is to use an open-ended cylinder and scrub the surface of the skin with a liquid substance. This method is useful for studying changes in the number of organisms under different environmental conditions but is very time consuming.⁴ The number of organisms is increased by the duration of rubbing, pressure exerted, and moistening the swab. Sticky tape sampling may also provide semi-quantitative data. Material for a full-thickness skin biopsy would be the best sample for bacterial quantification, but in practice it is expensive and invasive. The media used for isolation of the bacteria are also important. In general, ordinary blood or serum agar for aerobic organisms and solid Brewer's thioglycollate medium without indicator but with 1% Tween-80 for *Propionibacterium acnes* would be the best choice.⁵ Also there are newer molecular genetic methods, with extraction of the DNA of responsible microorganisms combined with processing and amplification. Broad-range polymerase chain reaction primers target highly conserved regions of bacteria and provide amplification of the small subunit ribosomal RNA gene sequences.⁶

In the case of normal bacterial flora, some variations exist within subjects and even within the same subject over time. Similarly, different anatomic localizations of the skin also differ in bacterial concentrations. Dry skin leads to a low level of colonization, whereas moist areas, such as skin folds and areas with more sebaceous glands, contain large amounts of bacteria.⁷

The resident aerobic flora consists of gram-positive cocci of *Staphylococcus* species, *Micrococcus* species, and a variety of gram-positive rods, the coryneforms or diphtheroids. These coryneform organisms are mainly *Corynebacterium* species. The most important gram-negative residents are *Acinetobacter* species. *Propionibacterium* species are the main anaerobic residents and are mostly found from the deepest part of the infrainfundibulum up to the entrance of the acroinfundibulum of the hair follicles.⁸ Streptococci may be found as transients on perioral skin or other sites before the onset of impetigo. *Staphylococcus saccharolyticus* is an anaerobic *Staphylococcus* organism and a member of the normal flora. Coagulase-positive species *S aureus*, however, is not a normal flora member but can frequently be found in the anterior nares and perineal skin. Healthy axillary skin and toe clefts in shoe-wearing populations may also contain coagulase-positive species *S aureus*.

Environmental factors may also contribute to the composition of normal flora. Lack of proper hygiene and bathing do not increase the bacterial count. As the

temperature and humidity increase, the number of microorganisms also increases. The effects of increased hydration have been studied by covering the skin with plastic film. Occlusive topical products may be a risk factor for skin infections.⁹ The total flora increases greatly; in the early stages, coagulase-negative staphylococci and micrococci predominate, but later lipophilic coryneforms increase in number. *Pseudomonas aeruginosa* is commonly isolated from moist areas and in high-humidity atmospheres.¹⁰

Certain areas of the skin have specific floras that differ from those at other sites, quantitatively or qualitatively. The common organisms of the nasal vestibule are coagulase-negative staphylococci, micrococci, coryneforms, and *Streptococcus pyogenes*. The axillary region has a very high level of bacterial colonization, mostly staphylococci, micrococci, and coryneforms. Some individuals have a mainly coccal flora, whereas others mostly have aerobic coryneforms.¹¹ *Propionibacterium acnes* is usually present and *P avidum* is often found as *Acinetobacter* spp. The fourth toe cleft is often macerated in individuals who wear shoes for prolonged periods. In such conditions, large number of bacteria, mainly general residents of the flora and also Gram-negative organisms are found. The toe web is also an important area for *Brevibacterium* and *Acinetobacter* species.¹² Coagulase-negative staphylococci, micrococci, and aerobic coryneforms can be found in the perineum and groin regions.¹³

Function of the normal flora

The normal flora of the skin has several functions, the most important of which is to defend against pathogenic bacteria. Normal flora produce lipases and esterases that break down triglycerides into free fatty acids, resulting in a lower skin surface pH; such an acidic environment inhibits the growth of pathogens.¹⁴ Apocrine sweat is sterile and odorless when secreted. The odor develops due to bacterial secretions, mainly aerobic corynebacteria. Deodorants are effective largely through their antibacterial activity.¹⁵

Bacterial infections

The ability of bacteria to adhere to the skin surface depends on many factors. On wet surfaces, the hydrophobic nature of bacterial walls promotes sticking of the bacteria to skin. There is a tendency of the skin to stay moist and wet in the fold areas. As a result, a greater number of bacteria can adhere to the skin surface on these fold areas, and overgrowth of these bacteria can easily cause infections. In addition, outer surface proteins called adhesins promote adhesion.¹⁶ An example of bacterial adhesin is lipoteichoic acid, which is found in both staphylococci and streptococci.

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