Microbiological analysis of acute infections of the nail fold on the basis of bait thread test

Hanna Tomczak1, Aleksandra Dańczak-Pazdrowska2, Adriana Polańska3, Agnieszka Osmola-Mańkowska3, Jakub Pazdrowski4, Wioleta Błażejewska-Gąsior1, Anna Horla1, Marta Hasse-Cieślińska2, Zygmunt Adamski2

1Central Microbiological Laboratory, Święcicki University Hospital, Poznan, Poland
2Department of Dermatology, Poznan University of Medical Sciences, Poznan, Poland
3Department of Dermatology and Venereology, Poznan University of Medical Sciences, Poznan, Poland
4Head and Neck Surgery Ward, Laryngological Oncology Clinic, Poznan University of Medical Sciences, Poznan, Poland

Abstract

Introduction: An acute infection of the nail fold, called paronychia, is a common clinical problem. The basis for the implementation of the treatment is the result of microbiological examination. Due to the rapid and painful course of infection, usually an empirical antimicrobial treatment prior to obtaining microbiological test results is introduced.

Aim: The microbial analysis of acute infections of the nail fold.

Material and methods: The study included 32 tests conducted on 31 patients of the Department of Dermatology. Microbiological analysis was performed with the use of the so-called bait thread test.

Results: In 73% of analyzed cases microbiological examination revealed mixed microbiological flora. Most cultured microorganisms were: Enterococcus faecalis (14%), Staphylococcus aureus (12%), Candida albicans (9%), Enterobacter cloacae (8%), and Klebsiella pneumoniae (7%). Most cultured bacteria belonged to the families or genera of Enterobacteriaceae (36%), other cultured bacteria were staphylococci (26%), enterococci (16%), Candida species (14%), and Gram-negative non-fermenting bacilli (8%).

Conclusions: The acute infection of the nail fold in the vast majority of cases is caused by mixed bacterial flora. A profile of isolated microorganisms suggests that the cause of the infection can be associated with neglect of hygiene. Fluoroquinolone and fusidic acid are recommended as the empirical therapy. Microbiological examination is the basis for the appropriate final treatment.

Key words: paronychia, nail fold, infection, Enterobacteriaceae, staphylococci, bait thread test.

Introduction

Acute infection of the nail fold, called paronychia, is a common clinical problem. From the dermatological point of view it is characterized by the presence of erythema, swelling and pain, which mostly are observed within the dominant hand, particularly the thumb or index finger. In most of cases it is caused by infection. This infection may result from minor injuries like nail biting, finger sucking or aggressive manicuring. Very important risk factors include diabetes mellitus and exposure to moisture conditions in a workplace. Therefore, cooks, launderesses, housekeepers and physical workers (mostly in rural areas) are specially predisposed to paronychia [1–6]. Table 1 summarizes the possible diseases/conditions and occupations associated with an increased tendency to paronychia [7]. The basis for the implementation of the treatment is a result of microbiological examination of the swab obtained from the nail fold. However, it should be noted that not always purulent discharge from the nail plate is detected [2]. In such circumstances, the recommended examination is the use of a so-called bait thread test [7, 8]. Bait thread test was introduced by Alkiewicz (world famous Polish mycologist) to detect nail fold yeast infections. In this test the cotton sterile thread, which is soaked with Sabouraud broth, is placed underneath the nail fold for 24 h. After removing, thread is cultured [9, 10].

Due to the rapid and painful course of infection, usually prior to obtaining microbiological test results, an
empirical antimicrobial treatment is introduced. What is more, this is desirable as the infection may continue to spread and involve the tendons or deep spaces of the hand, leading even to the amputation of the phalanx [11].

Aim

Therefore, the aim of this study was the analysis of microbial infections of the nail fold based on the so-called bait thread test in patients treated in the Department of Dermatology, Poznan University of Medical Sciences.

Material and methods

Microbiological analysis was performed with the use of the so-called bait thread test at the Central Laboratory of Microbiology in Święcicki University Hospital in Poznan in 2006–2011. This method was previously described in the literature by Alkiewicz and was based on the localization of the sterile thread soaked in Sabouraud broth underneath the nail fold for several hours [8–10, 12].

The study included 32 tests conducted on patients of the Department of Dermatology, University of Medical Sciences in whom, on the basis of the clinical picture, acute nail fold infection was suspected (Figure 1). In 2 cases (2 women), the results were negative – no growth of the pathogenic flora. The remaining 30 studies were taken from 29 patients (24 women, 5 men) and revealed the presence of the pathogenic flora. From 1 patient (male) the material was collected twice.

Each thread obtained from the patient was then placed in the broth medium in a tube (BHI – brain-heart broth, bioMerieux) for initial proliferation. After 24 h of

| Diseases/conditions            | Occupations                  |
|--------------------------------|------------------------------|
| Celiac disease                 | Hairdressers                 |
| Chronic lymphocytic leukemia    | Bartenders                   |
| Diabetes mellitus              | Builders                     |
| Frostbite                      | Cooks                        |
| Histiocytosis X                | Cosmetologists               |
| Hypoparathyroidism             | Dentists                     |
| Progressive systemic sclerosis  | Farmers                      |
| Psoriasis                      | Fishermen                    |
| Raynaud’s disease              | Housewives                   |
| Retinoids                      | Meat/raw food handlers       |
| Stevens-Johnson syndrome       | Mechanics                    |
| Systemic lupus erythematosus   | Pianists                     |
| Traumatic injury               | Waitresses/waiters           |
| Pemphigus                      | Masseurs                     |

Figure 1 A, B, C. Bait thread test
incubation, broth was cultured on solid media (bioMérieux): Columbia agar with 5% blood, MacConkey’s agar, Chapman Agar, D-coccusel Agar, Sabouraud agar with gentamicin and chloramphenicol. Cultured material was incubated under aerobic conditions in an incubator at 37°C for 24 h. Due to the absence of microbial growth on the first day after first culture, the cultivation time was extended to 48 h. After the period of incubation, 24 h for bacteria, 48 h for yeast, reading and further isolations were made. Finally the identification and assessment of the sensitivity to antibiotics or antifungal agents were performed. Identification of microorganisms was carried out using the bioMérieux VITEK system and bioMérieux ATB. Evaluation of sensitivity to antibiotics was performed in the automatic VITEK system. Organisms were also examined for the presence of resistance mechanisms.

Results
In the analyzed material 74 microorganisms were isolated. Pathogens were isolated from 30 tested threads. In 2 cases no microorganisms were cultured. The number of grown pathogens in 1 material ranged from 1 to 5 species, but only in 8 (27%) cases single microorganisms were isolated: Staphylococcus aureus (4 patients), Enterococcus faecalis (2 patients), Klebsiella pneumoniae (1 patient), and Escherichia coli (1 patient). In the remaining tests mixed flora was found (Figure 2).

The most common cultured organisms were (in the following order): Enterobacteriaceae – 27× (36%), staphylococci – 19× (26%), enterococci – 12× (16%), Candida species (spp.) – 10× (14%), and Gram-negative non-fermenting bacilli – 6× (8%) were detected (Figure 4). Among the Enterobacteriaceae family the following species were isolated: Enterobacter cloacae – 6× (22%), Klebsiella pneumoniae – 5× (18%), Escherichia coli – 3× (11%), Serratia marcescens – 3× (11%), Morganella morganii – 2× (7%), Citrobacter freundii – 2× (7%), Klebsiella oxytoca – 2× (7%), Proteus mirabilis – 2× (7%), Citrobacter braakii – 1× (4%), Providencia rettgeni – 1× (4%) (Figure 5). Among staphylococci: Staph. aureus – 9× (47%), Staph. haemolyticus – 4× (21%), and Staph. warneri – 3× (16%), Staph. saprophyticus – 1× (5%), Staph. epidermidis – 1× (5%), and Staph. lugdunensis – 1× (5%) (Figure 6). Among enterococci: Enterococcus faecalis – 10× (83%), Enterococcus faecium – 1× (8%), Enterococcus avium – 1× (8%). Among fungi: Candida albicans – 7× (70%) and Candida parapsilosis – 3× (30%). Among Gram-negative non-fermenting bacilli: Pseudomonas aeruginosa – 3× (50%), Acinetobacter lwoffii – 2× (33%), and Acinetobacter baumanii – 1× (17%).

Fungi of the genus Candida were isolated in 10 cases, representing 14% of the studies. These have always appeared together with 2–4 other pathogens, never as a single pathogen.

Among the strains of Enterobacteriaceae family all isolated strains were susceptible to most antibiotics (multisusceptible microorganisms), that were probably

![Figure 2. Number of pathogens isolated from one sample](image)

![Figure 3. Most commonly isolated pathogens](image)
own strains, the so-called wild. Twenty seven strains were cultured and analyzed. All analyzed strains were sensitive to amikacin, ciprofloxacin, second generation of cephalosporins – cefoxitin, third and fourth generation of cephalosporins (cefotaxime, ceftriaxone, cefepime), piperacillin/tazobactam, carbapenems (imipenem and meropenem), ticarcillin/clavulan acid. 96% were sensitive to gentamicin and trimethoprim/sulfamethoxazole, 63% to ampicillin/sulbactam or amoxicillin/clavulan acid, 40% to cephalothin (first-generation cephalosporin), 20% to cefazolin (first-generation cephalosporin) and 19% to ampicillin.

Among staphylococci, Staph. aureus revealed 100% sensitivity to fusidic acid, chloramphenicol, rifampicin, trimethoprim/sulfamethoxazole, gentamicin, vancomycin, teicoplanin, 88% to ofloxacin (representing quinolones), 77% to clindamycin and tetracycline, 62% to fosfomycin, and 44% to erythromycin. Coagulase-negative staphylococci (Staph. haemolyticus, Staph. warneri, Staph. saprophyticus, Staph. epidermidis) and Staph. lugdunensis demonstrated 100% sensitivity to rifampicin and vancomycin, 90% to trimethoprim/sulfamethoxazole, 88% to ofloxacin, 80% to lincomycin (clindamycin), 60% to tobramycin, 50% to erythromycin and fusidic acid and 30% to teicoplanin.

Susceptibility of enterococci was as follows: 100% sensitive to linezolid, moxifloxacin (representing quinolones), vancomycin, levofloxacin, 92% to penicillin, 75% to gentamycin, and 30% to tetracycline.

All cultured Candida were susceptible to amphotericin B and 5-fluorocytosine, 70% to fluconazole, and 60% to itraconazole and voriconazole.

All Gram-negative non-fermenting bacilli were sensitive to gentamicin, imipenem, meropenem, ceftazidime, cefepime, ciprofloxacin, 83% to ampicillin/sulbactam, 18% to cephalothin (first-generation cephalosporin), 14% to cefazolin (first-generation cephalosporin) and 13% to ampicillin.

Discussion
Paronychia is one of the most frequently observed localized hand infections, which clinically can be divided into an acute and chronic form [3]. The acute type of infection usually arises spontaneously as a result of bacterial growth due to the different trauma. This form...
is associated with intense pain and tenderness of peri-
onychium, provoked by collection of pus. On the other
hand, the chronic type is more often detected among
patients, who are continuously exposed to moist con-
tions, like bartenders, housekeepers, homemakers,
dishwashers and swimmers (Table 1) [3, 7, 13–15]. It’s
case is multi-factorial and includes Candida, low-grade
bacterial infection, prolonged contact with contactants
and irritants. From the clinical point of view, nail plates
become thickened and discolored, the cuticle is reddened
and pain is not so intense like in the acute form. It has to
be underlined that in patients with recurrent infection,
fungal infection should be always considered [3, 7].

In the presented material, nail fold infection was
more frequently observed among women, which is con-
firmed in the literature [5, 12]. Usually mixed infections
caused by 2 to 5 different pathogens were observed (73% 
of the samples), similarly to previous studies [1, 16]. In
27% (8 cases), the infection was caused by one patho-
gen. Then Staph. aureus (4 patients), Enterococcus fæ-
calis (2 patients), Klebsiella pneumonia (1 patient), and
Escherichia coli (1 patient) were isolated.

Among the most frequently isolated families or gen-
era are the following: Enterobacteriaceae (representing
36%), staphylococci (26%), enterococci (16%), Candida sp.
(14%), and Gram-negative non-fermenting bacilli (8%).
In the literature, among the more commonly indicated pathogens are enterococci, Enterobacteriaceae, Staphy-
lococcus and Gram-negative non-fermenting bacilli [2, 16].
The most common infectious pathogen is Staph. aureus [3, 4, 17]. Rarely cultured bacteria are anaerobic ones [11]. Among them Gram-positive cocci, Bacteroides
spp. and Fusobacterium spp. are the most frequent [16].
It has to be stressed that in all study cases coagulase-
negative staphylococci were isolated as a component of
mixed flora. It is unclear whether they play a real role
in paronychia or they are just contaminants. However
methicillin-resistant strains should be considered as
pathogenic. Moreover, coagulase-negative staphylococci
can form biofilm and for example they can be responsible
for catheter-related bloodstream infection [18]. The bac-
terial flora detected in our study is largely typical for
the anogenital area. Similar results were observed by Iranian
researchers [1].

Fungi of the genus Candida were isolated only in
14% of samples. Rare presence of yeast in nail fold infec-
tion was also noted by other authors [16]. In addition, it
should be emphasized that none of our results suggested
that fungi of the genus Candida are the single pathogen.
In all cases they were a component of mixed fungobacte-
rial infection. Additionally, the number of accompanied
bacterial pathogens ranged from 2 to 4. Among fungal
infections, the most frequently isolated fungi were Can-
dida albicans, and then Candida parapsilosis, which was
confirmed in previous reports [12]. In the literature there
are also descriptions of other species of the genus Can-
dida, which may be occasionally a pathogenic factor in
the nail fold infections, including Candida guilliermondii,
Candida glabrata, Candida tropicalis and Candida kefyr
[1, 12]. They were not isolated in this study.

Microbiological analysis of sensitivity to antibiotics
indicates usefulness of fluoroquinolones (ciprofloxacin,
ofloxacin, moxifloxacin, levofloxacin) in the treatment of
paronychia because 100% of the isolated Enterobacteri-
aeae were enterococci and Gram-negative non-ferment-
ing bacilli and 88% staphylococci were sensitive to them.
However, the latter were in 100% sensitive to topical use
of fusidic acid. This is an important issue in clinical prac-
tice, when a decision on empiric antibiotic therapy prior
to obtaining a result of microbiological culture is made.
The effectiveness of fluoroquinolones was also pointed
by Eames et al. [19]. Importantly, the authors based their
opinion on the microbiological analysis. These findings
differ from the recommendations found in two papers of
Rigopoulos et al. and Rockwell, who assumed that oral
antibiotics should have primary antistaphylococcal ac-
tion and suggested the use of amoxicillin with clavulanic
acid, clindamycin and trimethoprim with sulfamethoxa-
zeole [3, 4]. Our analysis of susceptibility revealed that
these drugs in empiric antibiotic therapy are not justified.
On the other hand, among antifungal agents nystatin ap-
pears to be useful. This drug belongs to the same group
as amphotericin B, which showed sensitivity of 100% of
the tested strains. It should be noted that in this analy-
sis, sensitivity of Candida spp. to fluconazole and itra-
conazole was only 70% and 60%, respectively. Due to the
significant toxicity of these agents, one should therefore
refrain from a decision on their inclusion until the result
of the evaluation of their sensitivity is obtained.

To sum up, it should be emphasized that the acute
infection of the nail fold in the vast majority of cases is
a mixed flora infection. A profile of isolated microorgan-
isms suggests that the cause of the infection in many
cases can be associated with neglect of hygiene. Most
frequently isolated bacteria belong to the Enterobacte-
riaceae, followed by staphylococci. For this reason, the
preferred empirical treatment is a combination of fluoro-
quinolone and fusidic acid. The basis for the appropriate
treatment is properly performed microbiological exami-
nation with the evaluation of susceptibility [20]. Due to
the possibility of different etiological factors for infec-
tions with different resistance formula, there is a need
to conduct periodic microbiological analyses on larger
groups of subjects in a variety of environments.

Conclusions

Paronychia is an important clinical problem, which
usually affects women. The bait thread test is a useful
diagnostic tool to detect causative agents of paronychia.
Mixed flora (including Enterobacteriaceae and staphylo-
cocci) is responsible for most cases of nail fold infections.
Proposed empirical treatment of paronychia should include a combination of fluoroquinolone and fusidic acid. Neglect of hygiene is a risk factor for paronychia.

Conflict of interest
The authors declare no conflict of interest.

References
1. Thappa DM, Kumari R, Singh R, et al. Evaluation of role of Candida in patients with chronic paronychia. Indian J Dermatol Venereol Leprol 2015; 81: 485-90.
2. Baran E. Wybrane choroby paznokci. Przew Lek 2000; 6: 67-70.
3. Rockwell PG. Acute and chronic paronychia. Am Fam Phys 2001; 63: 1113-6.
4. Rigopoulos D, Larios G, Gregoriou S, Alevizos A. Acute and chronic paronychia. Am Fam Physician 2008; 77: 339-46.
5. Durdu M, Ruocco V. Clinical and cytologic features of antibiotic-resistant acute paronychia. J Am Acad Dermatol 2014; 70: 120-6.
6. Chang P. Diagnosis using the proximal and lateral nail folds. Dermatol Clin 2015; 33: 207-41.
7. Daniel CR 3rd. Diagnosis of Onychomycosis and Other Nail Disorders. A pictorial atlas. Springer, New York, 1996.
8. Hasse-Cieślińska M. Diagnostyka i leczenie powierzchownych zakażeń grzybiczych. Przew Lek 2006; 7: 109-20.
9. Adamski Z, Batura-Gabriel H. Mikologia lekarska dla lekarzy i studentów. Uniwersytet Medyczny im. K. Marcinkowskiego w Poznaniu, Poznan 2007.
10. Prochacki H. Podstawy mikologii lekarskiej. PZWL, Warsaw 1975.
11. Riesbeck K. Paronychia due to Prevotella bivia that resulted in amputation: fast and correct bacteriological diagnosis is crucial. J Clin Microbiol 2003; 41: 4901-3.
12. Krzemieńska-Jaskowiak E, Dembińska M, Cybulski Z, et al. Grzybica i bakteryjna flora wałów paznokciowych u pacjentów z wieloogniskowym zakażeniem Candida spp. Mikol Lek 2003; 10: 249-53.
13. Hochman LG. Paronychia: more than just an abscess. Int J Dermatol 1995; 34: 385-6.
14. Jebson PJ. Infections of the fingertip. Paronychias and felons. Hand Clin 1998; 14: 547-55.
15. Jules KT, Bonar PL. Nail infections. Clin Podiatr Med Surg 1989; 6: 403-16.
16. Brook I. Aerobic and anaerobic microbiology of paronychia. Ann Emerg Med 1990; 19: 994-6.
17. Małeszka R, Ratajczak-Stefańska V, Różewicka-Czabańska M. Zmiany infekcyjne paznokci. Przegl Dermatol 2011; 98: 120-7.
18. Smuszkiewicz P, Trojanowska I, Tomczak H. Venous catheter microbiological monitoring. Necessity or a habit? Med Sci Monitor 2009; 15: SCS-8.
19. Eames T, Grabein B, Kroth J, Wollenberg A. Microbiological analysis of epidermal growth factor receptor inhibitor therapy-associated paronychia. JEADV 2010; 24: 958-60.
20. Tomczak H, Dańczak-Pazdrowska A, Horla A, et al. Estimation of vancomycin MIC for Staphylococcus aureus in patients treated in the Chair and Department of Dermatology, Poznan University of Medical Sciences. Postep Derm Alergol 2011; 28: 462-6.