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Original Article

Epidemiological characteristics and inflammation markers in simple hand infections

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Abstract: Background: The epidemiological characteristics and bacteriological spectrum of simple hand infections vary from region to region. Moreover, the relevance of preoperative laboratory inflammatory markers in clinically diagnosed hand infections is controversial and has not been examinated thoroughly yet. Patients and methods: A retrospective analysis of the data of 180 patients with simple hand infections treated operatively between 2008 and 2015 was performed. The patients' age, gender, infection localization, purulence and etiology, as well as the preoperative leukocyte count and CRP level were collected from the patients' charts. Results: Fingers were most frequently affected (58%), followed by the metacarpus (22%) and the thumb (20%). The most common cause of infection was bite injuries (19%) followed by foreign bodies (18%), cuts (16%), prick injuries (14%), and thorns (12%). The most frequent bacterium found in the culture was *Staphylococcus aureus* (33%) followed by *Pasteurella multocida* (11%), *Staphylococcus epidermidis* (9%), and *Streptococcus viridans* (9%). No association between the leucocyte count or the CRP values and the number of different bacteria found in the culture or the existence of a purulent infection could be found. Conclusion: The variations in the localization of the infections and the bacteriological characteristics of simple hand infections depend on their etiology. Preoperative laboratory inflammation parameters do not seem to correlate with the severity of hand infection and thus play only a secondary role in operative indication.

Keywords: Hand infections, epidemiology, localization, bacteriological spectrum, etiology, inflammation markers

Introduction

Hand infections are routine hand surgical cases. Hand infections are usually classified according to their localization or type of injury, e.g. felon, tenosynovitis, thenar space infection, or clenched fist injury. Concerning the infection localizations, the fingers are most frequently affected, followed by the metacarpus and the thumb [1]. A classification system according to the severity of hand infections was proposed by the senior author in a previous work [2]. Class I infections were defined as simple infections without any effect on the tendons, bones, or joints, and are the topic of this work.

The cause and underlying microorganisms of hand infections differ among regions and hospitals with different focuses. In most cases, minor injuries such as cuts or prick injuries with or without incorporation of foreign bodies as well as bite injuries serve as the entry point. The bacterial spectrum found in hand infections depends on the cause of the injury, but it often includes species of the patient's resident microflora. About 65% of hand infections are caused by aerobic, mainly gram-positive bacteria. The most common bacteria mentioned in the literature are *Staphylococcus aureus* (35-50%) and hemolytic streptococci (10%) [3]. In the case of bite injuries, species of *Pasteurella* and *Neisseria* are typically found in addition to the common bacteria mentioned above [4].

Due to the compartmental anatomy of the hand, infections may spread rapidly into deeper tissue layers and along anatomically predetermined conductive structures such as tendon sheets [5]. To prevent the spread of an infection, an early and meticulous surgical debride-

ment of the affected tissue is essential in most cases. A delay in adequate surgical treatment may lead to severe complications with permanent functional impairments [6]. In most hand trauma centers, surgical treatment is accompanied by the administration of antibiotics. In the case of simple hand infections without any affect on the tendons, bones, or joints, antibiotics seem to be unnecessary. They not only contribute to increasing antibiotic resistance, but they also may mask the symptoms of a progressive infection of the hand [2]. Especially in the USA, the increasing incidence of MRSA and germ resistance have also been reported and discussed in hand infections [7, 8].

Clinical examination is the main indicator for diagnosing a hand infection and making a decision whether a surgical debridement is necessary or not. Elevated inflammatory markers such as C-reactive protein (CRP) and the leukocyte count may support the indication for surgical treatment. CRP is a more sensitive indicator of the early phase of an acute hand infection, while an increase in the leukocyte count is an indicator of a significant bacterial infection. Both markers, but mainly CRP, may be influenced by other parameters or pathologies such as gout, smoking, stress, and medication, so they are not always specific enough [9].

The aim of this work is to present the epidemiological characteristics, the bacterial spectrum, and the impact of laboratory inflammation parameters in simple hand infections.

Patients and methods

Patients

A retrospective study was performed. An approval from the ethical committee of the Eberhard-Karl University in Tuebingen was obtained (project number 670/2013B01).

Between 2008 and 2015, the data from the charts of 180 patients with simple hand infections, who were treated surgically in our academic department, were collected. Included were up to 80 year-old adult patients, who were able to understand the background of the study. Simple hand infections were defined as infections without tendon, bone, or joint involvement in patients without immunodeficiency. Excluded were patients with severe infections accompanied by fever, lymphangitis or infections affecting the tendons and/or the bony structures, pregnant females, patients suffering from diabetes, immune failure, or other relevant secondary diseases. All the patients were subjected to radical debridement, lavage, and sufficient drainage on the day of their admission. A postoperative immobilization in a palmar cast was performed, usually for two to five days, depending on the clinical infection signs. The usual length of hospital stay was two to three days.

In the current paper, the epidemiological data, bacteriological characteristics, and preoperative laboratory inflammation parameters of simple hand infections will be presented. Epidemiologic data include patients' age, as well as localization, purulence and etiology of the infection. Localization documentation included the palmar or/and dorsal spread of the infection as well as the main distribution in the thumb, fingers, or metacarpus. Moreover, the preoperative levels of the inflammatory markers CRP and the leukocyte count were assessed and correlated to the frequency of the different bacteria found in the microbiological culture as well as the purulence of the infection.

Statistical analysis

To test the dependency between the leukocyte count or the CRP level and the number of bacteria found in the culture, a univariate regression model was calculated using chi-square tests. To determine whether any differences in the leukocyte count or CRP levels between the purulent and non-purulent infections existed, one-sample Mann-Whitney U tests were used. The level of significance was set to 0.05.

This work is reported in line with the STROCSS criteria [10].

Results

Among the 180 patients, 116 were males and 64 females. The age distribution ranged between 18 and 76 years old. The mean age of the male patients was 46, of the female patients 49, and of all patients 47.

Localization and purulence of the infections

90 hand infections (50%) were located on the palmar side, 59 infections (33%) on the dorsal side, and 31 (17%) extended both dorsally and

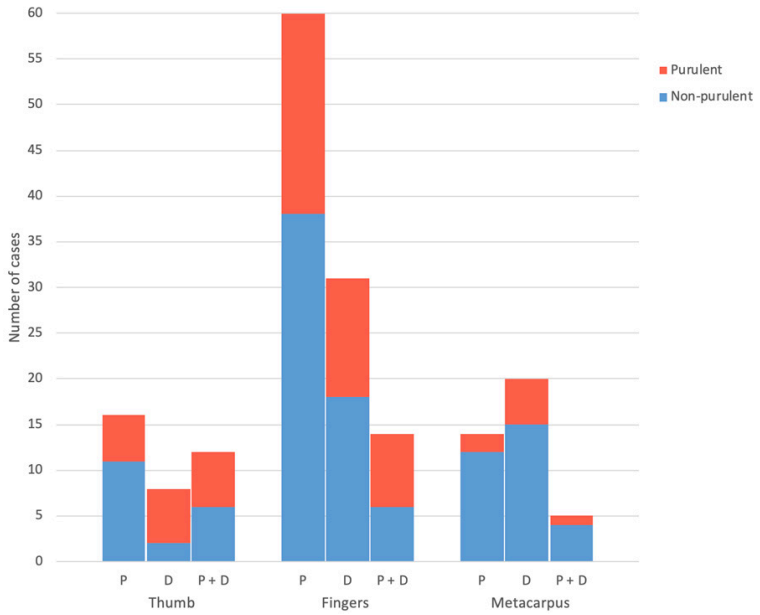

Figure 1. Distribution of infections on the palmar (P), dorsal (D) or both the palmar and dorsal (P + D) sides of the hand for the three localizations (thumb, fingers, and metacarpus) separately. The non-purulent infections are shown in blue and the purulent infections in red.

palmary. In 97 cases the affected hand was the right (54%) and in 83 cases the left one (46%). Fingers were most frequently affected; this was the case in 105 patients (58%). Furthermore, 39 infections were related to the metacarpus (22%) and 36 infections to the thumb (20%). In 113 cases (63%) the infection was non-purulent while 67 cases (37%) were purulent.

The distribution of the localizations and the purulence of all hand infections is summarized in **Figure 1**. Both the palmar and dorsal spreads of the infections were more frequent among the thumb infections (33%) than among the finger and metacarpal infections (13% in both cases). Purulent infections were more frequent among thumb and finger infections (47% and 41%, respectively) than among metacarpal infections (21%). Purulent infections were mostly found on the dorsal aspect of the thumb and the fingers; 60% of the thumb infections located dorsally or both dorsally and palmary were purulent, but only 32% of the thumb infections localized palmary were purulent. 47% of the finger infections localized dorsally or both dorsally and palmary were purulent, but only 37% of the finger infections localized palmary were purulent.

Etiology

In 171 of the 180 examined charts, the cause of the infection was documented. In 14 cases (8%) no obvious injury existed, so the cause was declared as unknown. The most common cause was bite injuries (19%) by cats in 82% or dogs in 18% of the cases. Further etiologies were foreign bodies (18%), cuts (16%), and prick injuries (14%), thorn injuries (12%) as well as crush injuries (7%). Other causes were only marginally observed. The distribution of all the etiologies of the infections is summarized in **Figure 2**.

Microbiological findings and laboratory inflammation parameters

In 161 of the 180 cases, microbiological examinations involving one or more intraoperative swabs were performed. In 43 of the examined cases (27%) no bacterial growth could be obtained. In 47 cases (29%) more than one bacterium could be found in the culture in terms of mixed infections. In only two cases a mixed infection with 5 and 7 different pathogens, respectively, could be found. In all other cases of mixed infections, two or three different bacteria were found in the culture. The most frequent bacterium was *Staphylococcus aureus*, found in 53 cases (33%), followed by *Pasteurella multocida* (11%), *Staphylococcus epidermidis* (9%), streptococcus viridans (9%) and beta-hemolytic streptococcus (6%).

In 126 of the 180 cases, the leukocyte count, and in 124 of the 180 cases the CRP were determined preoperatively. Only in 20 cases (16%) was the leukocyte count elevated (range 10.1-16.2 × 1000/µl), but the CRP was elevated in 76 cases (60%, range 5.9-74 mg/l). In 13 cases (10%) both the leukocyte count and the CRP were elevated, and in 83 cases (66%) at least one inflammatory marker was elevated. The frequency of the different bacteria as well the leukocyte counts and CRP levels found in each case (if determined) are illustrated in

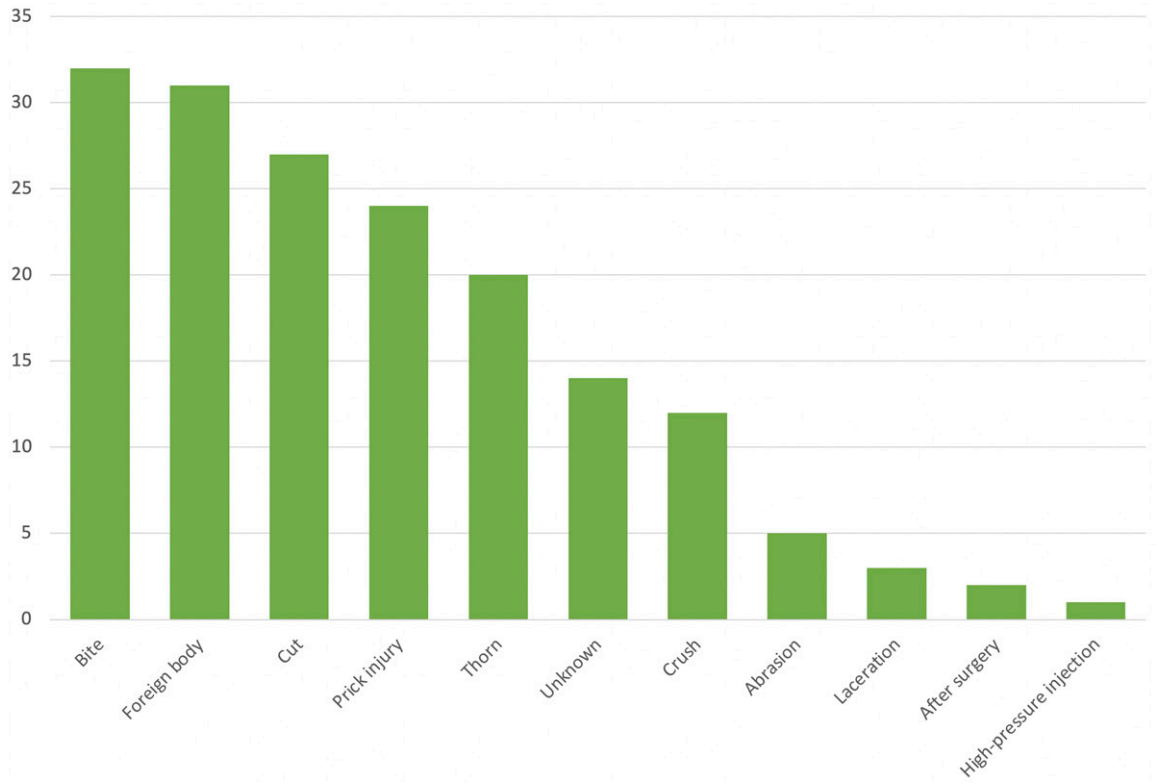

Figure 2. Distribution of the causes of the hand infections.

Figure 3. In a univariate regression model, no association between leucocyte count or CRP values and the number of different bacteria found in the culture could be found (P = 0.15 and P = 0.28, respectively). Moreover, no significant differences in the levels of leucocyte count or CRP level could be found between the purulent and non-purulent infections (P = 0.33 and P = 0.16, respectively).

Discussion

The data from the 180 patients with simple hand infections were assessed retrospectively to evaluate their epidemiologic characteristics including the localizations and the severity (non-purulent versus purulent), the etiologies, the bacteriologic spectra, as well as the laboratory inflammation parameters. Almost two thirds of the patients were males. This is mostly correlated to the fact that males are more likely exposed to minor or major injuries of the hand, than females are, due to manual work.

Localization and purulence of the infections

67% of the hand infections examined in this study were located palmary or both palmary and dorsally, making the palmar side the most frequently affected side of the hand. This can be logically explained by the fact that the palmar side, as the gripping side of the hand, is more frequently exposed to injures than the dorsal side. Fingers were the most frequently involved in 58% cases, followed by the metacarpus in 22% and the thumb in 20% of the cases. These results are concordant to findings in the literature. Türker et al. examined 94 patients with infections of the upper extremity, of which 79 of them were located in the hand, and compared their localizations with other authors. 58% of the hand infections were located in the fingers, 25% in the metacarpus, and 16% in the thumb [1]. The fingers and the thumb are the first and most distal parts of the body used for palpation and gripping and are therefore more susceptible to infections.

Concerning the severity of the hand infections, 63% of the cases were non-purulent and 37% were purulent. This implies that patients access the outpatient department early due to the restrictive symptoms caused by the simple hand infections [6, 11]. Because of the septal anatomy of the hand, inflammation easily causes increased pressure and painful swelling

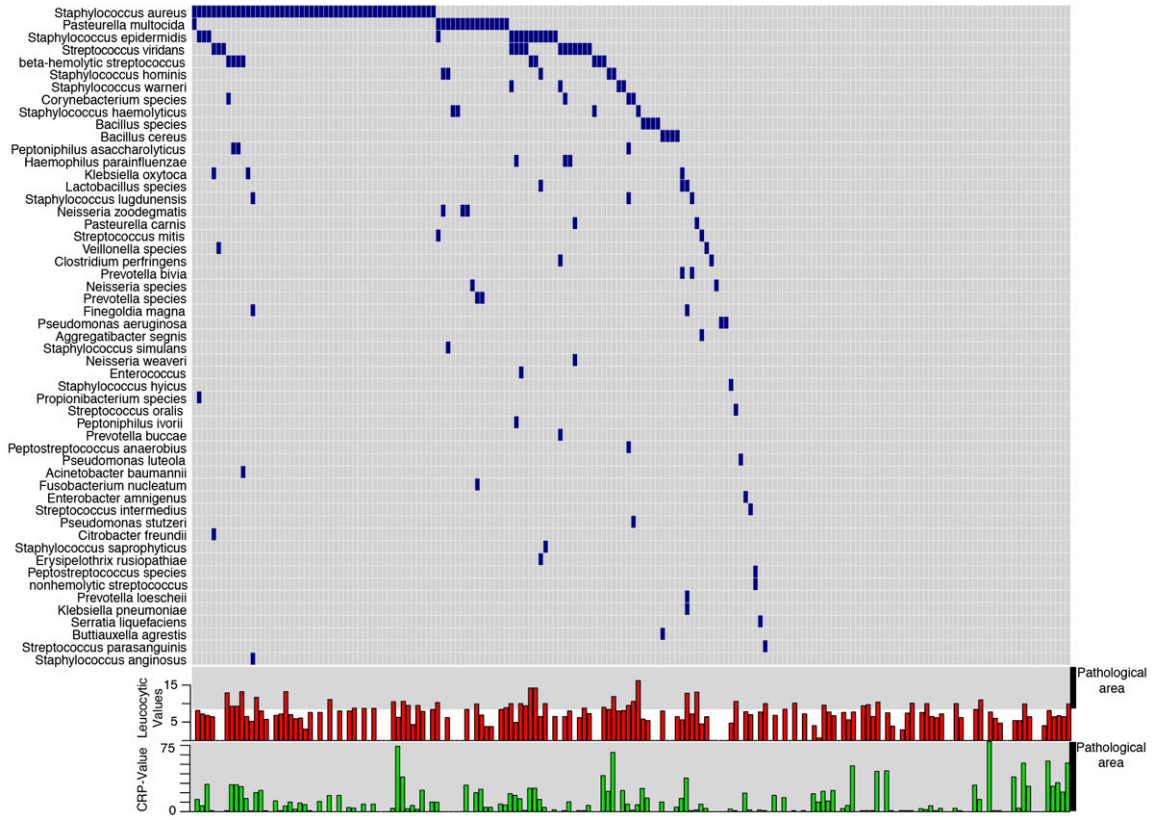

Figure 3. The frequencies of the different bacteria in all the included hand infections. On the right side of the plot no blue rectangles exist for the cases without any growth of bacteria or without intraoperative swabs. On the bottom of the plot, the corresponding leukocytic and CRP values are shown for each case.

in the soft tissue, which is notable and intolerable for the patient. Moreover, more severe infections that spread to the tendons, bones, or joints were excluded from the study. Purulent infections were more often found in the fingers and the thumb and more rarely in the metacarpal area. Infections in the metacarpal area cause early significant symptoms, so the patients with infections in this area are more likely to be treated earlier. In the fingers and the thumb, purulent infections were found more frequently dorsally than palmary. This can also be explained by the earlier onset of symptoms at the palmar side of the fingers and the thumb than at their dorsal side.

Etiology

The most common cause of infections was bite injuries (19%) followed by foreign body incorporation (18%), cuts (16%) prick injuries (14%) and thorns (12%). These results are largely consistent with the current literature, but bite injuries were slightly more common in our study than described by Türker et al. (11%) [1]. The infection rate after a bite injury of the hand is higher than in other parts of the body and is estimated to be 30-40%. This is based on the compartmental anatomy of the hand [4] and the aggressive pathogens found in the saliva, whereas anaerobic bacteria may lead in more severe infections [12]. In general, cat bites lead more likely to manifest infections of the hand than dog bites. This is due to the sharp and small teeth of the cats that inject bacteria in deep tissue layers, causing small wounds without sufficient drainage. On the other hand, dog bites result in more superficial crush wounds with better drainage [13]. Therefore, there was a much higher frequency of cat bites compared to dog bites as a cause of hand infections in our study.

Microbiological findings and laboratory inflammation parameters

The most commonly-detected bacteria in the hand infections not caused by bites were *Sta-*

phylococcus aureus, *Staphylococcus epidermidis*, and streptococcus species. These results agree with the findings of earlier studies [3, 14, 15]. The second most frequently detected bacterium was *Pasteurella multocida*, which is commonly found after bite injuries [16, 17]. Mixed infections with usually 2-3 different pathogens were found in 29% of the cases. In the literature, mixed infections are described in up to 84% of the cases in studies originating mainly from the USA [1, 18]. In a Danish study, mixed infections were found in only 12% of cases [3]. These differences can be explained by the different regional and epidemiological characteristics of the previous studies. A notable observation was that no bacterial growth was found in more than one fourth of the examined intraoperative swabs. In the literature no bacterial growth could be found in 11-30% of the examined cases [1, 3, 19]. An explanation could be that other untested pathogens like viruses or fungi cause the infection or that not enough pathogens were present at the time and site of the intraoperative swab. However, it should be kept in mind that acute inflammation may occur also without the presence of any pathogens.

CRP was more frequently elevated preoperatively than leukocyte count (in 60% versus in 15% of cases). This observation illustrates that CRP is a more sensitive inflammation marker but may be elevated also in other pathologies like gout and chronic inflammatory disease [9]. An elevation of the leukocyte count occurs if an infection cannot be controlled locally by the immune system, so it can be considered a marker for a more severe infection. However, this could not be validated in the current study. A new aspect was that no significant difference in the leukocyte count or CRP levels between the purulent and non-purulent infections could be found. Moreover, no association between the leukocyte count or the CRP values and the number of different bacteria found in the culture could be demonstrated. Finally, 34% of the patients with a clinically diagnosed hand infection and preoperatively determined laboratory inflammatory markers demonstrated no elevation of leukocyte count or CRP. These observations underline the importance of the clinical evaluation of the hand infections. Laboratory inflammation parameters do not seem to play a mandatory role in indicating an operative treatment. Typical clinical symptoms such as hyperthermia, pulsating pain causing sleep disturbances and loss of function still remain the main indicators for surgical treatment.

A limitation of the study was the retrospective design. Therefore, not all parameters like intraoperative swabs or preoperative laboratory inflammation markers were assessed in all cases.

Conclusion

The palmar side of the fingers is the most frequent localization for hand infections. *Pasteurellla multocida* is, along with *Staphylococcus aureus*, one of the main pathogens of hand infections due to an increase in animal bites, which were the most common cause of infection in this study. However, the presence of pathogens in the cultures of intraoperative swabs is not obligatory. Elevated inflammation markers like the leukocyte count and CRP may support the diagnosis but are not necessarily correlated with the severity of the infection and may not even be elevated in clinically obvious hand infections.

Disclosure of conflict of interest

None.

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