Epidemiology of bacterial hand infections

Shirzad Houshian*, Sedigheh Seyedipour, Niels Wedderkopp

Department of Orthopaedics, Hand Section, Odense University Hospital, Sdr. Boulevard 29, DK-5000 Odense C, Denmark

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KEYWORDS
Hand infection; Bacteriology; Site of injury; Laboratory tests; Complications

Summary
Objective: The aim of the study was to delineate and update the bacteriological spectrum, characterize patterns and sites of injury, evaluate laboratory tests and possible causes of complications in patients with bacterial hand infections.

Methods: All hand infections operated on in the department of orthopedics at Odense University Hospital during the period 1992—2001 were reviewed retrospectively. A standard protocol was used to collect data for each patient. We also examined all laboratory reports and recorded the identity of the etiologic organism, if known, for all cases of bacterial hand infections.

Results: Four hundred and eighteen patients (296 men and 122 women) with hand infections were operated on between 1992 and 2001 in our department. The median age of the patients was 40 years (range 1—93). The average interval from primary injury to operation was 10 days (range 1—50). The etiology was laceration/puncture in 35%. The site of infection was subcutaneous in 45% followed by tendon, joint and bone in 27, 18 and 5%, respectively. The bacteria isolated from the patients showed that 184 cultures (44%) were pure Staphylococcus aureus followed by 49 cultures (11.7%) of mixed organisms. Body temperature and C-reactive protein (CRP) were normal in three quarters of all patients with hand infections in our series. However the erythrocyte sedimentation rate (ESR) was elevated in 50% of the patients and was a significantly better test for infection in this study than CRP (p = 0.002). Neither the severity of infection nor the etiology of infection was related in any way to the initial temperature, CRP or ESR in this study. Complications were noted in 14.8% of all patients, and were especially related to diabetes, and mixed infection.

Conclusion: Despite modern antibiotics, hand infections with a variety of organisms continue to be a source of morbidity and possible long-term disability. Most hand infections are the result of minor wounds that have been neglected. A complete history and physical examination is necessary to exclude other associated medical conditions (diabetes, arthritis, immunosuppression) that may compromise therapy. Furthermore, our study confirms that Staphylococcus aureus is responsible for most instances of hand infection, followed by mixed organisms. Gram-negative organisms are frequently cultured in patients with diabetes and intravenous drug abuse.

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* Corresponding author. Current address: University Hospital Lewisham, Lewisham High Street, London, SE13 6LH, UK.
Tel.: +44 208 333 3030x6015; fax: +44 208 333 3159.
E-mail address: shirzad.houshian@uhl.nhs.uk (S. Houshian).

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Introduction

Hand infections pose difficult diagnostic problems because of the wide differential diagnosis that must be considered and the complex microbiology and anatomy involved. The prompt and accurate diagnosis of the nature, etiology, site of infection and bacteriological results is vital for a good outcome.

Hand infections are usually caused by common flora of the skin and mouth such as *Staphylococcus* spp and *Streptococcus* spp. It has been reported that approximately 60% of hand infections are caused by *Staphylococcus aureus*, with 86% of cultures growing only a single organism. More recently, prospective studies have shown that between 60 and 90% of all cultures are mixed, with *staphylococci* and *streptococci* present in roughly equal numbers.

The most frequent cause of significant hand infection is a neglected wound, and delay in presentation has a significant adverse effect on recovery. It has been stated that a bite is the most common single mechanism for causing an infected wound, human bites being responsible for 20–30% and animal bites for 5–10%. The aim of the present retrospective study was to delineate and update the bacteriological spectrum, characterize patterns, sites and causes of injury, evaluate laboratory tests, and determine possible causes of complications in established hand infections in patients operated on in our unit over a 10-year period from 1992 to 2001.

Patients and methods

All hand infections operated on in the Department of Orthopaedics at Odense University Hospital in the period from 1992 to 2001 were reviewed retrospectively, excluding simple paronychia in adults (these are dealt with in the accident and emergency room). A standard protocol was used to collect data for each patient. We also examined all laboratory tests, and recorded the identity of the etiologic organism, if known, for all cases of bacterial hand infections.

The definitions of hand infection used in our study were: (1) purulent drainage from the surgical incision; (2) organisms isolated from an aseptically obtained culture of sinus swab or tissue; and (3) spontaneous wound dehiscence with secretion of pus.

On admission, body temperature was evaluated in all patients. Between 1992 and 1997 routine erythrocyte sedimentation rate (ESR) tests were carried out, and since 1997 routine C-reactive protein (CRP) tests have been taken on admission. After discharge, all patients were regularly followed in the outpatient clinic and seen by a hand therapist if necessary.

Anatomical localization of hand infection was classified into five zones: zone I, distal interphalangeal (DIP) joint and distal to it; zone II, proximal interphalangeal (PIP) joint and distal to it, but proximal to DIP joint; zone III, metacarpal-phalangeal (MP) joint and distal to it, but proximal to PIP joint; zone IV, thenar and midpalmar space; zone V, wrist joint.

Surgical intervention

All patients were taken to the operating room for adequate surgical debridement under general anesthesia or regional anesthesia. In all cases, a pneumatic tourniquet was used to produce a bloodless field. The procedures comprised surgical wound exploration, debridement, and primary closure over a glove drain. In the case of flexor tenosynovial or joint infection, primary closure was performed over an indwelling irrigation catheter. The wounds were inspected within 24 hours, irrigated and debrided again if necessary. After surgery, plaster immobilization and elevation was performed followed by early remobilization after 2–5 days.

Bacteriology

Samples for bacteriological investigation were taken from pus, inflammatory exudate or preferably infected tissue at the time of surgery. Care was taken to ensure that the culture of specimens would reflect the flora deep within the wound rather than on the surface.

Antibiotic treatment

All patients except those with animal or human bites received parenteral dicloxacillin (1 g, 3 times daily) after operative cultures had been obtained. If the cultures revealed organisms resistant to the preselected antibiotic, the treatment was changed accordingly. In the cases with animal or human bites, patients received parenteral penicillin V. Infections associated with intravenous drug abuse and diabetes mellitus are suspect for *Gram-negative organisms* and gentamicin was added to the dicloxacillin. In cases of mixed infection including both β-hemolytic *streptococci* and *Staphylococcus aureus*, penicillin V was added to the treatment with dicloxacillin. Changes in oral therapy were based on the clinical response.

Statistics

All calculations were performed using Stata 8.2 software (StataCorp LP, College Station, TX, USA), where adequate continuous variables with normally distributed residuals were described with means. Differences between groups were illustrated using differences between means with 95% confidence intervals (95% CI). Variables with non-normal distributed residuals were described using medians, and differences between groups were illustrated with differences between calculated medians with 95% CI. Differences between categorical variables were assessed using Fisher’s exact test.

Patients were evaluated in the out-patient clinic for range of motion (ROM) and pain before discharging. Distance from the pulp of the fingertip to the palmar flexion crease (PFP) at the end of treatment was assessed in 322 patients. This is a categorical variable with six categories: 0 cm (normal), 0.1–1 cm, 1.1–2 cm, 2.1–3 cm, 3.1–4 cm, and more than 4 cm. The relative risk of an abnormal PFP was assessed with 95% CI.

Results

During the 10-year period between 1992 and 2001, a total of 418 persons with definitive hand infections were operated on. There were 296 men (71%) and 122 women (29%). The median age of the patients was 40 years (range 1–93). The average interval from primary injury to operation was 10 days (range 1–50).
The mechanisms of injury are shown in Table 1. Possible predisposing factors were diabetes (35 cases), intravenous drug abuse (21 cases), alcoholism (13 cases), steroid usage (ten cases), gout (eight cases) and rheumatoid arthritis (six cases).

Anatomical localizations of the infections are shown in Table 2. Site/type of hand infections are shown in Table 3.

Type of infection in relation to predisposing factors showed that intravenous drug users developed subcutaneous infections in zone IV in most cases. Out of thirty-five patients with diabetes, 51% developed subcutaneous infection, and tendon, joint and bone infection in 34, 6 and 9%, respectively. Frequency of organisms isolated on culture and relation to etiology are shown in Table 4.

Tenderness, redness and swelling were seen in 322 patients (77%), redness and swelling alone in 43 patients (10.3%), tenderness and swelling in 25 patients (6%) and a description was missing for 28 patients (6.7%). Temperature on admission was under 37°C in 298 patients (71.3%), above 37°C and under 38.5°C in 66 patients (15.8%), over 38.5°C in 22 patients (5.3%) and unknown in 32 patients (7.7%). CRP on admission was normal (<10 mg/l) in 131 patients (63%), slightly elevated (11–20 mg/l) in 12 patients (5.8%), elevated above 20 mg/l in 38 patients (18.4%) and unknown in 26 (12.6%) patients. ESR on admission was normal (<5 mm/h) in 94 patients (36.4%), slightly elevated (>5 and <30 mm/h) in 85 patients (33%), elevated above 30 mm/h in 29 patients (11.2%), and unknown in 50 patients (19.4%).

In 108 patients both tests were performed. In these patients CRP was normal in 86 (79.6%), in six it was slightly elevated (5.6%), and in 16 (14.8%) it was elevated. ESR was normal in 36 patients (33.3%), slightly elevated in 55 (50.9%) and elevated in 17 (15.7%). ESR was a significantly better test for infection in this study than CRP (p = 0.002).

Complications occurred in 62 patients (14.8%) and included persistent infection requiring further debridement in 30 cases (7.2%), amputation of the digit in 14 cases (3.3%), stiffness in 11 cases (2.6%), arthrodesis in five cases (1.2%), and other complications in two cases (0.5%); there were no complications in 356 cases (85.2%). Complications in relation to cultured organism showed 23 cases of Staphylococcus aureus, 13 cases of mixed organisms, 11 cases of β-hemolytic streptococci, and other in 15 cases. Complications in relation to predisposing factors showed that in 21 cases (34%) it was related to diabetes (amputation in 11 cases and further operation in 10 cases). Sixty percent of the patients with diabetes developed a complication compared to 10.7% of patients without diabetes (p < 0.001). No other predisposing factors were related to an increased number of complications.

The relative risk of not obtaining normal PFP after postoperative complications was 2.4 (95% CI 1.6; 3.6). Significantly more patients that had had complications did not return to normal PFP (p < 0.001). The median interval onset of infection to operation was six days (95% CI 5; 7) in the complications group and six days (95% CI 4; 11) for the non-complications group; difference between medians was −1 (95% CI −2; −1). Patients with and without complications were hospitalized a median of 6.5 (95% CI 16; 8) and 4 days (95% CI 13; 4), respectively; difference between medians was −3 (95% CI −4; −2).

### Discussion

The essential principles for the surgical management of hand infections have been well established by numerous authors. Successful management is largely a consequence of surgical incision, debridement and drainage, but also new investigations into the microbiology and antibiotic therapy of these infections have contributed. Despite increased attention, hand infections continue to present serious problems with immediate morbidity and potential long-term disability. Delays and inadequate treatment can result in significant complication rates as high as 70%. Most previous reports have concentrated on one etiology such as animal bite or human bite and their relation to bacteriology and antibiotic treatment. Only few publications on hand infections including all possible etiologies have been reported in the literature.
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<th>Laceration</th>
<th>Foreign body</th>
<th>Animal bites</th>
<th>Previous surgery</th>
<th>Human bites</th>
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Early reports in the late 1960s showed 80% of hand infections to be due to *Staphylococcus aureus* and 16% to streptococcal species, with 86% of cultures growing only a single organism. The incidence of pure *Staphylococcus aureus* infection decreased from 80% in 1960 to 20% in late 1980. The incidence of pure *Staphylococcus aureus* infection was 44% in our study. More recently, prospective studies have shown that between 60 and 90% of all cultures are mixed (on average two or three different organisms per culture) with staphylococci and streptococci present in roughly equal numbers. In the present study this was found to be reduced at 11.7%. In our study, no bacterial growth was found in 11% of cases. There might be several possible reasons for this. First, prescribing antibiotics before obtaining cultures of specimens is known to interfere with the recovery of causative agents by culture. Second, it may have been under-detected because of inadequate techniques for isolation and identification in the period covered.

Anaerobic bacteria are associated particularly with bite wounds, intravenous drug use, and diabetes mellitus, and have been identified in up to 30% of hand infections, depending on the patient population. Previous culture and bacterial sensitivity studies of human and animal wounds have shown an incidence of mixed infections in up to 30% of cases. There might be several possible reasons for this. First, prescribing antibiotics before obtaining cultures of specimens is known to interfere with the recovery of causative agents by culture. Second, it may have been under-detected because of inadequate techniques for isolation and identification in the period covered.

In conclusion, despite the weaknesses and limitations of this retrospective study, it demonstrates that *Staphylococcus aureus* is responsible for most instances of hand infection, followed by mixed organisms. Gram-negative organisms are frequently cultured in patients with diabetes and intravenous drug abuse. Despite modern antibiotics, hand infections with a variety of organisms continue to be a source of morbidity and possible long-term disability. Most hand infections are the result of minor wounds that have been neglected. A complete history and physical examination is necessary to exclude other associated medical conditions (diabetes, arthritis, immunosuppression) that may compromise therapy. The history should ascertain the mechanism of injury, as this may provide some clues about the organisms involved.

*Conflict of interest:* No conflict of interest to declare.

**References**