

Hand Infections

Lucas S. McDonald, MD, MPH, Mary F. Bavaro, MD, Eric P. Hofmeister, MD, Leo T. Kroonen, MD

Hand infections are commonly seen by orthopedic surgeons as well as emergency room and primary care physicians. Identifying the cause of the infection and initiating prompt and appropriate medical or surgical treatment can prevent substantial morbidity. The most common bacteria implicated in hand infections remain *Staphylococcus aureus* and *Streptococcus* species. Methicillin-resistant *S aureus* infections have become prevalent and represent a difficult problem best treated with empiric antibiotic therapy until the organism can be confirmed. Other organisms can be involved in specific situations that will be reviewed. Types of infections include cellulitis, superficial abscesses, deep abscesses, septic arthritis, and osteomyelitis. In recent years, treatment of these infections has become challenging owing to increased virulence of some organisms and drug resistance. Treatment involves a combination of proper antimicrobial therapy, immobilization, edema control, and adequate surgical therapy. Best practice management requires use of appropriate diagnostic tools, understanding by the surgeon of the unique and complex anatomy of the hand, and proper antibiotic selection in consultation with infectious disease specialists. (*J Hand Surg* 2011;36A:1403–1412. © 2011 Published by Elsevier Inc. on behalf of the American Society for Surgery of the Hand.)

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the surgeon of the unique and complex anatomy of the hand, and proper antibiotic selection in consultation with infectious disease specialists. This article reviews basics of microbiology in addition to specific infections and their treatment based on anatomic location.

MICROBIOLOGY

The most common bacteria associated with hand infections, *Staphylococcus aureus*, is implicated in up to 80% of infections.¹ Other common microbes include *Streptococcus spp*, Gram-negative organisms, and viruses. Most infections result from injury occurring at home or in the workplace and involve Gram-positive organisms. Infections associated with farm injuries, bite wounds, intravenous drug use, and immunocompromised conditions, including diabetes mellitus and human immunodeficiency virus, are often polymicrobial.^{1–5} Fungi and atypical mycobacteria can present as more indolent infections that can be difficult to diagnose and treat. Specific cultures and stains should be requested based on the clinically suspected organism.

Hand infections resulting from methicillin-resistant *S aureus* (MRSA) have increased in the past decade.

From the Division of Hand and Microvascular Surgery, Department of Orthopedic Surgery, and Division of Infectious Diseases, Department of Internal Medicine, Naval Medical Center San Diego, San Diego, CA.

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Corresponding author: Leo T. Kroonen, MD, Department of Orthopaedic Surgery, Naval Medical Center San Diego, 34800 Bob Wilson Drive, Suite 112, San Diego, CA 92134; e-mail: leo.kroonen@med.navy.mil.

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Methicillin-resistant *S aureus* first appeared as a nosocomial infection in 1961, 1 year after introduction of the penicillin class that included methicillin.⁶ Since then, the presence of both nosocomial and community-acquired MRSA infections has continued to rise, and over the past decade the rate of MRSA in *Staphylococcus* infections has grown to 34% to 78%.^{6–11} Populations at increased risk of MRSA infections include patients with diabetes mellitus, a history of antibiotic use, and an immunocompromised state; intravenous drug users; patients who participate in contact sports; military recruits; children enrolled in daycare; and prison inmates and homeless individuals.^{6,10,11} Risk factors for developing nosocomial MRSA infections include intensive care unit stays, lengthy antibiotic therapy, surgical procedures, lengthy hospitalization, and close proximity to hospitalized patients who are colonized or infected with MRSA.¹⁰

In conjunction with the rapid rise in MRSA infection rates, there has been great interest in identifying and treating hand infections. A recent review examined time to treatment with adequate, culture-sensitive antibiotics for hand infections and found that patients with MRSA infections experienced a delay of more than 2 days before appropriate antibiotics were started. This suggests possible grounds for empiric treatment for hand infections that includes coverage for MRSA.⁸ Hospitals have begun instituting treatment algorithms for hand infections to better treat this emerging pathogen. In a study at Temple University, the risk factors and severity of infection were assessed before initiation of treatment, and therapy was then directed toward suspected methicillin-sensitive *S aureus* (MSSA) or MRSA infections, as appropriate. Following this algorithm, 41 of 47 patients with MRSA infections and 37 of 38 non-MRSA infections were initially treated with adequate empiric antibiotics but with no significant difference in time to start of appropriate therapy or length of hospital stay.⁶ Parkland Hospital also reviewed treatment of hand infections and, based on a delay in treatment for MRSA infections, modified the treatment algorithm to empirically treat all hand infections for MRSA pending culture results.⁷ Based on the rapid increase in MRSA as a pathogen and the potential implications for delay in treatment, it is recommended that institutions develop a treatment algorithm for hand infections that includes routine cultures before starting antibiotics, empiric treatment for MRSA infections,

contact isolation protocols, and subsequent culture-specific antimicrobials, when available.

FINGER INFECTIONS

Paronychia

A paronychia is an infection beneath the eponychial fold. Risk factors for development include manicures, fingernail biting, and hangnails. With acute infections, a painful, swollen area develops under the nail fold. *Staphylococcus aureus* is the usual inciting organism; purulent drainage is not always present in early infections. Over time, purulent drainage inevitably develops, necessitating surgical drainage. Simple paronychia can be treated with a digital block and placement of a small clamp on the nail sulcus to drain the purulent material. If allowed to progress, infections spread under the nail fold or even under the nail itself. This requires a more aggressive treatment, including elevating the nail fold, partially or completely removing the nail, and occasionally, incising proximally into the eponychium. Surgical treatment of the abscess is the critical part of treatment, but antibiotics are important as adjunctive therapy.¹²

Chronic paronychia is a distinctly different process involving mixed flora of infectious agents, including fungal organisms. Infections tend to occur in individuals who have consistently moist hands, such as swimmers, dishwashers, and bartenders. It has an indolent course with multiple exacerbations and is difficult to treat. The most effective treatment is a combination of antifungals and a topical steroid (3% clioquinol in triamcinolone-nystatin mixture), but often surgical treatment with nail plate removal or marsupialization of all affected tissue is required.¹²

Felon

A felon is a closed-space infection of the distal finger pulp, most commonly associated with *S aureus*. Kana-vel¹³ described the distal phalanx as a “closed sac” of connective tissue that is separated from the rest of the finger and further subdivided by multiple septae. When inoculated with an infectious agent, a localized abscess can easily develop in the distal pulp, accompanied by swelling, throbbing pain, and erythema. If caught early in the course, infection can at times be treated with elevation, soaks, and antibiotics. However, most cases do not present until after abscess formation and must be treated surgically.¹² The option for type of incision has been controversial; we recommend a high-lateral incision (Fig. 1). The incision should be made just below the fingernail to prevent disruption of the volar fat pad and damage to the digital artery or nerve. For the thumb, incisions should be made radially, and for all



FIGURE 1: To drain a felon, a high lateral incision should be made and followed by blunt dissection across all septae in the distal pulp to assure complete decompression.

other digits, ulnarly, to prevent painful scarring with pinch grip of the digits. All septae should be broken up with blunt dissection and a drain left in place. Patients should be given empiric antibiotics and immobilized, with strict elevation instituted, until healing is shown to progress.

Herpetic whitlow

Herpetic whitlow is a herpes simplex virus infection involving the hand. Infections typically result from inoculation of an open area of skin with either herpes simplex virus (HSV)-1 or HSV-2. Once the virus infects epithelial cells, the virus replicates, leading to infection presenting as vesicles at the site of inoculation. The virus may then migrate via a nerve until it reaches the dorsal root ganglion that corresponds to the primary area of skin infected by the virus. After resolution of the infection, the virus can remain dormant and become reactivated at a later date. The virus is spread by direct contact with infected individuals; it is considered an occupational hazard for individuals who handle oral-tracheal secretions, including dentists, dental hygienists, anesthesiologists, nurses, and other health care providers. Children may present with hand lesions related to sucking their thumb or biting their nails during an HSV-1 outbreak. Adults may present with HSV-1 or -2 infections related to primary or recurrent orolabial or genital infections. Cases have been described in patients after human bites.¹⁴

Patients with herpetic whitlow typically present with throbbing pain in the infected finger, followed by the development of vesicular lesions, usually over the fingertip. These lesions coalesce, drain clear to turbid fluid, and then mature to ulcers. The course is typically self-limited over a 1- to 2-week period. Patients may also present with systemic symptoms of a viral illness, including fevers, malaise, and lymphadenitis. Diagnosis is clinical but can be confirmed with a Tzanck smear and viral cultures of the outer base of the ulcer. Treatment is often supportive with the goal of preventing spread or secondary infections. Therapy with acyclovir may shorten the course of disease if initiated within the first 48 to 72 hours of illness. After the initial infection has cleared, the virus remains in a latent state in the nervous ganglia, with the capability of causing multiple recurrences.¹⁵ Factors including sun exposure, mental or physical stress, and concomitant infections can precipitate recurrent infections. Many individuals experience a prodrome of tingling sensation in the area of infection. Acyclovir has been recommended for treatment to prevent recurrences or to shorten recurrent infections in individuals who experience prodromal symptoms. Incision and drainage is not recommended, given the potential risk for bacterial superinfection.^{14,16}

Pyogenic flexor tenosynovitis

Pyogenic flexor tenosynovitis is a bacterial infection of the flexor tendon sheath between the visceral layer on the flexor tendon and the parietal layer, most commonly associated with *S aureus*, after a penetrating trauma. The sheath contains the flexor tendons and runs from the distal interphalangeal joint proximally to the A1 pulley. The thumb flexor tendon sheath and the radial bursa are contiguous. The small finger sheath and ulna bursa are also contiguous. The radial and ulna bursae communicate via Parona's space (Fig. 2), with the radial and ulna bursae extending up to the carpal tunnel in up to 80% of people.^{1,16,17} Infections can spread to the radial and ulna bursae connections, with spread to small finger flexor tendon sheaths, resulting in a horseshoe abscess. Proximal spread into Parona's space can also occur.¹⁷

Kanavel's¹³ 4 cardinal symptoms and signs of pyogenic flexor tenosynovitis include exquisite tenderness over the course of the sheath, limited to the sheath; semiflexed position of the finger; exquisite pain on extending the finger, most marked at the proximal end where definite swelling often may be seen; and symmetrical swelling of the entire finger. Not all of these signs will be present, but when flexor tenosynovitis is suspected, treatment should be instituted immediately

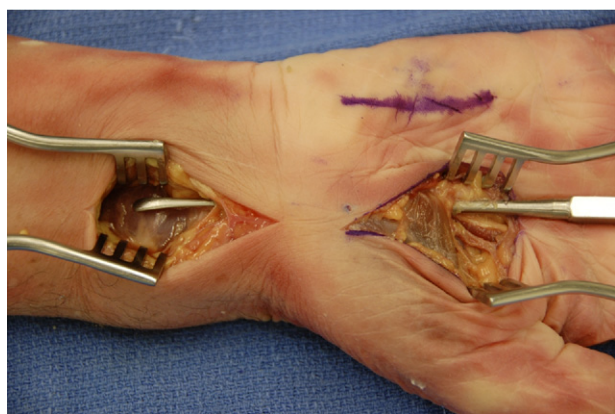


FIGURE 2: The thenar space is exposed with visualization of the radial bursa. An instrument can easily be passed proximally into Parona's space, demonstrating how infections can propagate proximally.

to prevent disastrous complications, including tendon adhesions or even necrosis. Early infections in physiologically healthy individuals diagnosed within 24 hours can undergo an attempt at nonoperative treatment, including immobilization, intravenous antibiotics, and strict elevation. Operative intervention is necessary in most cases and should not be delayed in the ill patient. Open midlateral or zigzag, Brunner-type incisions have been described, although there is a concern for flap-tip necrosis in the latter. After debridement, the incisions can be closed over an irrigation drainage system.¹⁸ Limited incision treatment can also be used, which allows a more rapid recovery. One incision is made just proximal to the A1 pulley at the level of the distal palmar crease, and a second is made midlateral or volar in the distal interphalangeal flexion crease, allowing irrigation to pass through the tendon sheath. A single 5F pediatric feeding tube is passed into the sheath and sutured in place, ensuring it is entirely in the sheath to prevent the possibility of a compartment syndrome if irrigation fluid is passed into the tissue of the hand. The hand is placed in a well-padded splint and irrigated with 10 to 20 mL normal saline with or without added lidocaine for comfort, 3 times daily for 48 to 72 hours. A similar procedure has been described using 2 feeding tubes of slightly different sizes that overlap in the tendon sheath, which allows for continuous irrigation without leakage.¹⁹ Risk factors for a poor outcome in pyogenic flexor tenosynovitis include age over 43 years, diabetes mellitus, peripheral vascular disease, renal failure, subcutaneous purulence, digital ischemia, and polymicrobial infections.²⁰



FIGURE 3: Thenar and hypothenar incisions should be made in line with skin creases with blunt dissection down into the closed space.

INFECTIONS INVOLVING THE HAND

Deep space infections of the hand are usually the result of contiguous spread of infection from other areas of the hand, penetrating trauma, or rarely, hematogenous spread. Deep spaces of the hand can be divided into the dorsal subaponeurotic, the thenar, the midpalmar, Parona's quadrilateral, and the interdigital subfascial web space. The mainstay of treatment for these infections is incision and drainage with administration of appropriate antibiotics.²¹

The boundaries of the dorsal subaponeurotic space include the extensor tendons dorsally and the metacarpals and interosseous muscles volarly. Infections present with dorsal hand swelling and may be difficult to distinguish from subcutaneous abscesses. Incisions for drainage should not be made over the extensor tendons, but rather over the second metacarpal and the space between the fourth and fifth metacarpals followed by early motion and local wound care.^{16,21}

On the volar side of the hand, the boundaries of the thenar space are the adductor pollicis dorsally, the index finger flexor tendon volarly, the adductor pollicis insertion on the proximal phalanx radially, and the midpalmar septum ulnarly. Thenar and first web space swelling are present with the thumb held palmarly abducted, allowing the greatest volume in the thenar space. Index finger flexor tenosynovitis and penetrating trauma are usually responsible for these infections, and they can easily spread into the dorsal first web space or cause a "pantaloony" abscess by spreading into the space between adductor pollicis and the first dorsal interosseous muscles.²¹ Incisions for drainage can be dorsal, palmar, or a combined approach, but should avoid running parallel to the first web space to prevent web contracture (Fig. 3).¹⁶ Wounds can be closed over an

irrigation catheter or left open and packed with daily wet-to-dry dressing changes.

The midpalmar or deep palmar space is bordered dorsally by the long and ring finger metacarpals and interosseous muscles, volarly by flexor tendons and lumbrical muscles, radially by the midpalmar septum, and ulnarly by the hypothenar muscles. Infection usually results from direct penetration, although it can occasionally result from contiguous spread from long or ring finger flexor sheaths.^{16,21} On physical examination, volar hand swelling is notable, such that the normal palmar concavity is lost and appears either flattened or convex. The entire hand usually becomes swollen, and active and passive movement of the long and ring fingers cause considerable pain. Operative treatment consists of a transverse distal palmar incision, an oblique longitudinal incision, a distal approach through the third interspace, or a combined longitudinal-transverse approach. Regardless of incision choice, a large exposure is preferable, with the wound either closed over irrigation catheters or left open and packed with wet-to-dry dressings daily.¹⁶

A collar button abscess is a subfascial infection of a web space that spreads peripherally at both dorsal and volar ends but remains narrow in the middle. It resembles the dumbbell shape of old collar buttons and usually starts with a volarly based nidus that is forced dorsally through the lumbrical canal by the adherent volar skin and fascia. It presents with signs of a volar infection and considerable dorsal web-space swelling. Treatment is with both a volar incision and excision of the fascia allowing drainage of the entire abscess or by incisions over the site of infection both volarly and dorsally. Incisions should not be made through the web space because this can cause contracture. Wounds should be allowed to close by secondary intention.^{16,21}

More proximally, Parona's space can become involved by spread of infection from either the radial or ulnar bursa. This results in pain with finger flexion and can even cause an acute carpal tunnel syndrome. Treatment is an open surgical debridement while avoiding damage to the median nerve and flexor tendons.

OTHER INFECTIONS

Cellulitis

Cellulitis is a spreading, diffuse inflammation of the skin with leukocyte infiltration but without underlying abscess formation. Breaks in the skin contribute to its occurrence but are not required. Usual causal organisms include *S aureus* and *S pyogenes*, and treatment is nonsurgical. Empiric oral or intravenous antibiotics should be started, based on a clinical judgment of the

severity, exposure history, and local practice guidelines. In view of the current rates of community-acquired MRSA, coverage should include coverage for MRSA in addition to that of MSSA and *Streptococcus spp.* The limb should be immobilized and strict elevation undertaken, with a low threshold for admission and observation.²²

Abscess

Subcutaneous abscesses usually develop from a simple puncture wound and present with a central fluctuant area surrounded by cellulitis. *Staphylococcus aureus* remains the most common organism. Treatment requires incision and drainage with culture before administering empiric antibiotic therapy. Therapy is tailored to culture-specific antimicrobials when results become available.

Fungal infections

Fungal infections of the hand can be separated into 4 broad categories: cutaneous, subcutaneous, deep, and systemic infections.²³ Cutaneous infections are those of the skin and nails and include tinea corporis (glabrous skin), tinea manuum (palms), and onychomycosis (nails). Definitive diagnosis requires fungal cultures through potassium hydroxide preparations. For simple infections, treatment is with topical antifungal agents, although treatment of onychomycosis remains much more difficult. Successful cure rates with oral griseofulvin or ketoconazole remain only 57% to 80%.²³ Alternatives, including oral terbinafine and weekly fluconazole, have similar response rates.

Fungal infections involving the soft tissue of the hand are not common but need to be included in the differential diagnosis of a patient who presents with a hand infection. If a fungal infection is considered, fungal cultures need to be ordered. Sporotrichosis is one of the most common subcutaneous fungal lesions in North America and almost exclusively occurs in the upper extremities.²³ This subcutaneous infection occurs after puncture wounds while handling plants, specifically roses. Initially, the puncture site develops an ulceration that spreads along lymphatic chains, forming nodules. The definitive diagnosis requires cultures and is treated with oral potassium iodide or itraconazole. Infections involving histoplasmosis, blastomycosis, *Cryptococcus*, and coccidioidomycosis also need to be considered based on exposure history.

Deep fungal infections are less common, and the organisms are either virulent or opportunistic. Such infections are often seen in immunosuppressed patients and are spread via hematogenous means. Treatment is

surgical with appropriate antimicrobials and can require drastic means, including amputation or arthrodesis of fungal septic arthritis.

Mycobacterial infections

Mycobacterial infections, usually *Mycobacterium marinum*, are indolent disease processes that often affect the hand. (Full discussion of these infections will be covered in another Current Concepts article.)

Septic arthritis

Septic arthritis is an infection of the joint space. Hand joint infections can result from direct joint penetration, contiguous spread, or hematogenous spread. Cartilage destruction results from the release of bacterial toxins, proteolytic enzymes, and other associated enzymes released during joint infection. With time, direct cartilage damage ensues, leading ultimately to osteomyelitis, and outcomes relate closely to the amount of time elapsed before adequate treatment.²⁴ *Staphylococcus aureus* and *Streptococcus spp* are still the most common bacterial organisms; nevertheless, *Gonococcus* should always remain on the differential diagnosis. Patients may present with a swollen, painful, erythematous joint held in partial flexion to maximize joint volume. Pain is present with any motion, and in cases of direct inoculation, a puncture wound may be present. If possible, joint aspiration should be performed to rule out noninfectious etiologies and to obtain cultures. Septic arthritis has joint aspiration findings of white blood cell counts greater than 50,000, with greater than 75% polymorphonuclear lymphocytes and a glucose level 40 mg less than fasting blood glucose level. Gram stains should be performed but may or may not demonstrate organisms.

Treatment should be by definitive incision and drainage, although some will treat with serial aspirations.²⁴ Straight incisions should be made to avoid flap-tip necrosis, and all purulent material and necrotic tissue should be removed. Postoperatively, the hand is splinted and maintained in strict elevation for 48 to 72 hours of treatment before starting active and passive motion. The wound can be left open to heal by secondary intention, closed over an intermittent or continuous irrigation catheter, or treated with delayed primary closure. The wrist joint should be entered between the third and fourth dorsal wrist compartments. Metacarpophalangeal joint incisions are also made dorsally entering through the proximal part of the sagittal band. Interphalangeal joints and the thumb metacarpophalangeal joint are entered through a midaxial incision, entering between the volar plate and the accessory collateral ligament to prevent damage to the extensor mechanism and

subsequent finger deformities.^{16,24} Intravenous antibiotics are started after obtaining cultures and continued for 4 weeks. In some cases, patients may be transitioned to oral therapy, depending on culture results.

Osteomyelitis

Osteomyelitis is an infection involving the bone and most often results from direct contamination by open fractures or contiguous spread after a traumatic event.²⁵ In children, and rarely in adults, hematogenous spread is also possible. As with most infections, *S aureus* and *Streptococcus* remain the common offending organisms. Atypical organisms, including Gram-negative, anaerobic, mycobacterial, and polymicrobial infections, present more commonly in immunocompromised patients including diabetics, or after crush-type injuries and injuries occurring in a contaminated environment.^{24–26} In the setting of open hand fractures or injuries, risks for osteomyelitis are reduced with satisfactory debridement and appropriate timing for reconstruction.

Presenting signs of osteomyelitis include pain, swelling, and erythema. Systemic symptoms are rare, presenting only in patients with overwhelming infections. Radiographic findings are almost invariably abnormal, with osteolysis being the most common finding (70%), followed by osteopenia (10%), osteosclerosis (10%), periosteal reactions (10%), and sequestrum or involucrum (5%) (Fig. 4).²⁵ Laboratory studies are rarely helpful in diagnosing osteomyelitis of the hand with regularly reported normal erythrocyte sedimentation rates and white blood cell counts.²⁵

Treatment of osteomyelitis can be attempted with parenteral antibiotics after obtaining a culture by periosteal or intramedullary aspiration. Optimally, once osteomyelitis has been diagnosed, most experts recommend surgical debridement and cortical windowing before starting antibiotic therapy.²⁴ Patients presenting with fever and systemic evidence of infection should have blood cultures drawn and empiric antibiotics initiated, immediately followed by appropriate imaging and surgical intervention. Antibiotics are tailored to specific organisms and sensitivities once they become available but should be continued either as parenteral or oral dosing for 4 to 6 weeks. Parenteral therapy is preferred for most cases of osteomyelitis; however, depending on the organism, isolated oral therapy may be appropriate. Changes in therapy should be made in consultation with an infectious diseases physician.²⁷

Bite wounds

Two classic types of human bites that occur are clenched fist injuries and true bite wounds (Fig. 5). A



FIGURE 4: A 49-year-old woman presented initially with swelling of her ring finger at the proximal interphalangeal joint. Initial radiographs showed normal bony anatomy and the presumed diagnosis was septic arthritis. Despite initial management with irrigation and debridement, her symptoms persisted. Three weeks later, her radiographs demonstrated osteopenia with cortical irregularity at the proximal interphalangeal joint, consistent with osteomyelitis (Image courtesy of Jennifer Green, MD).

wound over the metacarpal head must be assumed to be a clenched fist injury that involves the metacarpophalangeal joint until proven otherwise. Early on, this injury may not seem serious; however, providers must remember to examine the injury with the hand in the position the injury occurred. If examined with the fingers in extension, the tendon appears intact, but if brought back to the flexed position, the retracted tendon laceration is delivered into the skin wound, allowing visualization of a much more serious traumatic arthrotomy or open metacarpal fracture.^{1,2} True bite wounds usually do not involve the tendons or joints but should still be treated with aggressive treatment.

More than 40 bacterial strains have been isolated from human bite wounds; viral transmission is also possible.³ The most commonly isolated organisms include *S pyogenes*, *S aureus*, and *Eikenella corrodens*.^{3,28} The first 2 are common skin flora but *E corrodens*, a capnophilic Gram-negative rod that is a normal oral flora, is unique to human bites. *E corrodens* antibiotic susceptibility is unique, with susceptibility to penicillin and ampicillin but resistance to oxacillin, methicillin, nafcillin, and clindamycin.²⁸



FIGURE 5: A 29-year-old woman sustained this bite wound to her dominant small finger. Treatment involved antibiotic therapy, copious irrigation, and debridement, ensuring the bone of the distal phalanx was adequately covered. The finger was then allowed to granulate and heal by secondary intention.

Human bite wounds often present in a delayed fashion, more than 24 hours after injury, and should be considered infected. Evaluation includes physical examination and radiographs evaluating for fractures, foreign bodies, soft tissue swelling, and osteomyelitis. Human bite wounds that remain uninfected should be evaluated in the controlled environment of an operating room with extension of the incision, exploration of the extensor tendon and joint space, debridement, and irrigation. Postoperatively, the extremity should be splinted and elevated, and the patient should be admitted for intravenous antibiotics.^{16,28} Infected bites require a formal irrigation and debridement with hospitalization, immobilization, elevation, and intravenous antibiotic therapy, with repeat irrigation and debridement every 48 hours, as necessary.

Animal bites often involve the hand and in the United States are caused most commonly by dogs, cats, and rodents.^{3,29,30} Although much more common, dog bites rarely become infected, with reported rates at 4% compared with cat bites at 50%.³⁰ The anatomy and mechanism of biting for dogs and cats differ, and are likely responsible for these drastically different infection rates. Dog bites inflict injury by a crushing and tearing mechanism with teeth that are overall blunt in nature. Infectious agents are able to drain through these larger wounds. Cats' teeth, however, are sharp and pierce the soft tissues, leaving behind a trail of bacteria that acts much like a hypodermic needle. This mechanism creates a small break in the skin that heals quickly, thus trapping the bacteria in the deeper tissues. Com-

mon pathogens include *Staphylococcus*, *Streptococcus*, oral anaerobes, and *Pasteurella multocida*.^{3,5,29,30}

Presentation is either acute before infection has set in or late in the course of infection. Uninfected wounds should be treated with wound irrigation and extension for exploration of suspected bone, joint, or tendon sheath involvement. Antibiotic prophylaxis should be provided for these wounds.²⁹ Infected wounds necessitate operative incision and drainage with hospitalization for empiric intravenous antibiotics, wound care, splinting, and elevation.

Necrotizing fasciitis

Necrotizing fasciitis is a soft tissue infection that is a true surgical emergency. It usually occurs on the extremities after either small or large trauma.^{16,31} Individuals most at risk include those who are unemployed and who abuse alcohol or intravenous drugs. In fact, more than 60% of infections are precipitated by self-injection of substances into the upper extremities.^{31,32}

Presentation is often delayed multiple days after initial onset of symptoms, and early on, systemic signs may not be present. Symptoms of necrotizing fasciitis may include pain out of proportion to examination, violaceous bullae, cutaneous hemorrhage, skin sloughing, skin anesthesia (late finding), rapid progression, and gas in the tissue (crepitance).²² In many patients, these telltale signs may be absent.³² The diagnosis must be considered in patients with hemodynamic instability associated with what may be an otherwise unimpressive soft tissue infection.³²

Some cases may be polymicrobial; nevertheless, *S pyogenes* (group A streptococcus) is the most common organism associated with this infection.³² Anaerobes, *Aeromonas*, *Clostridium spp*, *Streptococcus spp*, and *Staphylococcus spp* have also been identified in cultures obtained from patients with necrotizing fasciitis infections.^{22,31,32} Necrotizing infections resulting from MRSA are increasing in incidence, and thus coverage for this organism should be included pending culture results.

When necrotizing fasciitis is suspected as a diagnosis, the first step with patients who present in shock is to resuscitate and initiate empiric intravenous antibiotics. This should be followed by urgent surgical debridement to remove all necrotic tissue. Adequate debridement is achieved by longitudinal incisions along the extremity and debridement of all necrotic tissue including muscle, fascia, fat, and skin (Fig. 6).³² Patients may require recurrent debridements until all the necrotic tissue has been removed and the infection is controlled. Definitive diagnosis is made by sending necrotic fascia for patho-



FIGURE 6: A 78-year-old man presented with systemic illness and a rapidly progressing dominant arm soft tissue infection. Early and aggressive management with serial wide surgical debridement, negative pressure therapy, and subsequent delayed closure allowed for preservation of the limb. Tissue sample confirmed the diagnosis of necrotizing fasciitis.

logic review, but classic findings include “dishwater pus” that is thin and foul smelling, subcutaneous vessel thrombosis, and skin, fat, and rarely muscle involvement.¹⁶ The fascia typically will appear swollen and dull and has areas of necrosis.^{22,33}

Cultures and Gram stains should be obtained and antibiotic therapy started emergently with empiric coverage, including vancomycin and clindamycin. Clindamycin is an important adjunct to therapy because of its ability to suppress toxin production and modulate cytokine production in both *S pyogenes* and *S aureus*.^{22,33} In cases where a Gram-negative bacterium or *Clostridium* species is possible, an extended spectrum beta-lactamase inhibitor antibiotic such as piperacillin, tazobactam, or a carbapenem should be added pending culture results. Outcomes do not depend on adequate antibiotic coverage, but most importantly by adequacy of debridement. Individuals older than 50 years of age, those with chronic illnesses or diabetes mellitus, and those with involvement of the trunk have worse outcomes.^{31,32} With strict adherence to principles of rapid and adequate debridement and broad-spectrum antibiotic coverage, the survival rate for upper extremity necrotizing fasciitis is over 90%.³²

Antimicrobial therapy

The choice of antimicrobial therapy in skin or soft tissue infections involving the hand should be based on the severity of infection, the depth of the infection, and the exposure history. In cases of patients requiring hospitalization, septic arthritis, osteomyelitis, and potentially tenosynovitis, a parenteral antibiotic regimen should be selected. In this era of increased MRSA, this

must be covered while awaiting culture results. Vancomycin remains the reference standard intravenous antibiotic for MRSA and is often the first choice in treating serious skin and soft tissue infections. Some infectious disease experts will add a beta-lactam antibiotic such as oxacillin or cefazolin for improved coverage of *S aureus*, given reports of treatment failures with vancomycin. For *S aureus*, either oxacillin or nafcillin, 2 g intravenously every 4 hours, remains the treatment of choice. For patients with a mild penicillin allergy, cefazolin is preferred. Vancomycin should be reserved for patients with MRSA or a history of a severe allergy to penicillin. Dosing of vancomycin for the patient with a history of severe penicillin allergy or MRSA should be titrated to achieve a trough of 15 to 20.^{22,34} Alternatives to vancomycin include linezolid, daptomycin, or telavancin.

In cases of less severe skin or soft tissue infections, oral antibiotics may be prescribed. Empiric therapy with either a tetracycline, such as minocycline or trimethoprim sulfamethoxazole, is preferred for MRSA. These antibiotics provide excellent coverage of *Staphylococcus*; however, they may miss *Streptococcus* species. A beta-lactam or a fluoroquinolone such as levofloxacin can be added to trimethoprim sulfamethoxazole for coverage of *Streptococcus* while awaiting wound culture results. Dicloxacillin is preferred for MSSA. Clindamycin is an alternative for both MSSA and MRSA in the patient with a penicillin allergy but should be avoided in patients with *S aureus* isolates resistant to erythromycin.^{22,34}

In the event of an infection with a Gram-negative bacterium, a fluoroquinolone such as ciprofloxacin or levofloxacin may be used; alternatives include amoxicillin clavulanic acid, tetracyclines, and trimethoprim sulfamethoxazole, depending on the culture results.

Empiric therapy for bite wounds should be ampicillin sulbactam for patients who require parenteral therapy and do not have a penicillin allergy. For outpatient therapy in the patient without a penicillin allergy, amoxicillin clavulanic acid is the preferred regimen. Patients with a penicillin allergy may be treated with parenteral or oral clindamycin, plus a fluoroquinolone such as ciprofloxacin or levofloxacin. Physicians may consider the addition of vancomycin for patients requiring hospitalization owing to the potential for an MRSA superinfection.²²

Duration of therapy should be based on the extent of the infection and should be discussed in consultation with an expert in infectious diseases. Typically, a superficial skin or soft tissue infection such as cellulitis

may be treated with 10 to 14 days of oral antibiotics. In cases of tenosynovitis, 3 weeks of parenteral antibiotics should be considered. Septic arthritis may be treated with 3 to 4 weeks of parenteral antibiotics, whereas osteomyelitis requires 4 to 6 weeks of parenteral antibiotics.

CONCLUSIONS

Hand infections include a diverse array of entities from finger infections to deep space infections and vary in etiology from viral to fungal to bacterial. Regardless of the cause or the responsible agent, they have potential for serious morbidity. To prevent disastrous complications, early identification and aggressive operative and medical therapy should be combined. Early consultation with an infectious diseases specialist can offer valuable information if the etiology is in question.

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