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Infections of Charcot Feet: Diagnostics and Treatment

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Abstract

Infections of Charcot feet unfortunately remain a common and difficult clinical problem. Because of the polyneuropathy of Charcot feet unrecognized skin lesions and trauma (external pressure) or exostoses (internal pressure) lead to ulceration with consecutive infections. Often these infections are diagnosed too late and still lead too often to amputation. It is essential to examine feet systematically for polyneuropathy and protect feet at risk from infections or detect existing infections as soon as possible. CN itself is a non-infective disease but secondary infections are common. It should be emphasized that any kind of polyneuropathy can cause CN even in the absence of diabetes. Superficial infections and deep infections with osteomyelitis have to be distinguished. If bone can be touched by swabbing osteomyelitis is very likely and represents an indication for surgical intervention in our opinion. Infected bones and soft tissue should be debrided thoroughly; the indication for second look operations should be generous in our opinion, if clinical signs of infections persist after 5-7 days. Amputations should be avoided whenever possible. Antibiotic treatment should be adapted to sensitivity testing of deep samples and maintained for at least 4 weeks. Often there are infections with either multiple germs or complicated bacteria such as MRSA or *P. aeruginosa.* After surgery the patient needs either protection shoes or, if necessary, customized orthopedic shoes or even orthoses. Side complications as elevated blood glucose level and circulation have to be optimized and the patient has to be informed and trained about his situation. A multidisciplinary team, consisting of orthopaedic surgeon, microbiologist, angiologist, orthopaedic shoe-maker, if necessary diabetologist and rheumatologist is needed.

Keywords: Charcot foot; Diabetes mellitus; Infection; Pseudomonas; MRSA; Surgery

Introduction

This article emphasizes the importance of diagnosing polyneuropathy in its early stages to prevent skin lesions and infections or detect superficial infections before spreading into deeper tissue. CN in its early stages especially in patients without diabetes mellitus must not be overlooked. Therefore ways to diagnose infections and especially distinguish between an acute stage of CN and osteomyelitis, which still leads to wrong diagnoses and remains difficult, are demonstrated. The next step is to propose useful and efficient treatment options in relation to stage and localization of infections and therefore improve treatment decisions. Especially concerning antibiotic treatment, surgery indications and techniques advices vary a lot. The goal is to improve the outcome especially of deep infections and therefore reduce the number of amputations.

Charcot Neuropathy (CN) itself is a non-infectious progressive disease of soft tissue and bone that leads to instability and destruction of joints [1] (Figure 1). Central role in the pathomechanism play the different kinds of polyneuropathy.

Charcot neuropathy (CN) of the foot represents a life-long high-risk condition for infections [1]. Due to the obligate polyneuropathy minor trauma and skin lesions are not recognized and the gate is opened for infections. These infections often stay unrecognized and undiagnosed for a long time and therefore can infiltrate deeper tissue. Charcot neuropathy represents a special condition; because the regulation of blood vessels is disturbed and immunologic reactions are impaired [1]. CN of the foot is often complicated by other diseases for example peripheral vessel disease, Diabetes mellitus, renal failure, rheumatoid arthritis [2]. Sharp and irregular exostosis can cause "internal" pressure leading to ulceration. Often these exocytosis can be felt under the skin, especially in the mid foot. Deep chronic osteomyelitis or even phlegmons still today lead to many amputations. More than 85% of the non-traumatic amputations in the US are preceded by ulceration [3]. Therefore the first and most important step to prevent and treat infections in CN of the foot is the early diagnosis of polyneuropathy before a "rocker-bottom foot" has developed and knowing the importance of prevention of skin lesions and ulcerations. Prevention of CN complications has the potential for significant financial savings. The cost for the primary treatment for a single diabetic ulceration is $7,000-$10,000 US dollars [4]. In a recent study Wukich et al. showed that early recognition and management of Charcot neuropathy can reduce complications [5]. John Bowker stated at the ISPO world congress in 2010 that 25% of all diabetic patients will develop ulcers and approximately 70-80% of these ulcers will be infected. It is important to state that diabetes is not the only reason for Charcot Neuropathy. In our previous studies and according to the recent literature alcohol abuse, toxic neuropathy for example induced by Methotrexat in rheumatoid patients, idiopathic neuropathy, hereditary neuropathy, syringomylia, leprosy, tumors, spinal cord injuries, amyloidosis and neurofibromatosis were different causes for Charcot Neuropathy [6-8]. These patients and feet at risk must not be overlooked.

Figure 1: CN of the foot with destruction of the mid- and hind foot and irregular bone loss as well as bone formation, superficial plantar ulceration without deep infection (sanders type II, III, University of Texas Wound Classification IB), status after "internal amputation" of os metatarsale II. The patient was treated with resection of plantar and medial exostosis, debridement of ulceration, offloading until wound healing.

Foot deformities in Charcot feet affect the forefoot, mid foot or hind foot.

CN of the foot is most often classified anatomically along the Sanders classification (Figure 2). Clinically, CN is classified by Eichenholtz in three clinical and radiological stages.

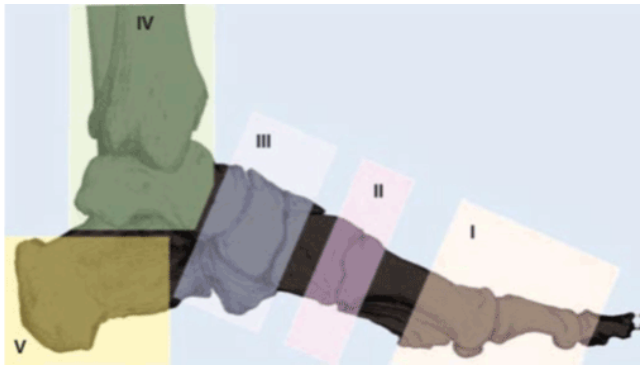

Figure 2: Sanders classification of CN of the foot.

Often different parts of the foot are affected, so that there is usually a combination of Sanders types. In our recent studies most often affected was the mid foot (Sanders II and III) in a collective of patients with foot reconstructions [2]. Sanders classification is based on radiological bone alterations.

Very often there a fore foot deformities especially hammer and claw toes. These toe deformities represent a high-risk situation for infection. Polyneuropathy starts peripheral, so first affected are the toes, often before polyneuropathy is diagnosed. The proximal interphalangeal joints or the tip of the first toe often show ulcerations. These ulcerations appear harmless in the beginning, but they are the gates for bacteria invasion. Because of the thin soft tissue layer osteomyelitis of the toes develops rapidly and spreading to the mid foot or even to the whole body by access to blood vessels represents a dangerous risk (Figure 3).

Figure 3: Contract claw toes with chronic ulceration of the proximal interphalangeal joint V in a patient with CN of the foot, severe polyneuropathy due to corticoid-induced diabetes mellitus because of rheumatoid arthritis. The patient was treated with resection of the ulcer, debridement and arthrodesis of the proximal interphalangeal joint using a k-wire that was removed after 3 weeks and antibiotic treatment for 4 weeks.

CN and ulceration of the mid foot show all kinds of malposition, instability and exostoses. To decide if a surgical intervention is necessary the stability of the foot has to be evaluated. Unstable situation will always lead to new ulceration. Hind foot infections are not as common as mid foot infections. Often we see deep infections penetrating Achill´s tendon or the calcaneus because of the thin soft tissue layer.

Infections should be classified according to the depth of infection and complications. Unfortunately there is still no common consensus on the classification system. Commonly used has been the classification of Wagner (Grade I = no infection to Grade V = gangrene of the foot). Oyibo at al. showed 2001 that the University of Texas Wound Classification System was a better predictor for patient ´s outcome, combining grade and stage of infection [10] (Table 1). These two classification systems have been developed for the Diabetic foot but can be used to classify ulceration in Charcot feet due to other diseases in our opinion. There are many other classification systems in use.

Diagnosis

Infection of Charcot feet is a clinical diagnosis, based on clinical examination of the local signs of infection and patients´ history. Important is to distinguish between an acute stage of CN and infection to prevent wrong treatment and complications. As mentioned above, a Charcot foot shows a (severe) polyneuropathy, usually with hyp- or anesthesia. Easy clinical tests using a Semmes-Weinstein-Monofilament and/or a tuning fork enable physicians to detect easily and cost effective polyneuropathy [11]. An acute CN of the foot usually shows a red, swollen and warm foot but if there is no super

infection CRP and leucocyte level are not elevated [2]. This is an important fact and first step to discriminating an infected from an acute Charcot foot without infection. If there has not been a skin lesion recently (in the last months) and infection parameters are normal, a red and swollen foot in a diabetic patient is probably an acute stage of CN and not an infection. In this case, immobilization in a total contact cast would be the treatment of choice. A high rate of reoccurrence related to obesity and noncompliance was shown by Osterhoff et al. [12]

Antibiotics are not necessary if there is no infection. In this situation, a thorough clinical examination and palpation of the whole foot should be the first step. X-rays of the whole foot with the patient standing should be performed next to classify the stage of CN and look for pseudexotoses that might cause ulceration in the future. We suggest dorso-plantar and side x-rays of the foot and frontal imaging of the ankle. CT or MRI can be performed for special cases but are usually not necessary in our opinion. Using an MRI, it still remains difficult to distinguish an infection from an active CN of the foot [13]. If there is a skin lesion or ulceration, then super infection and osteomyelitis (if the bone can be touched with a swab) are very likely (Figure 4). If this situation is present, thorough surgical debridement should be performed within one or two days, as the risk of sepsis is elevated in immune impaired diabetic patients [11].

	Grade 0	Grade I	Grade II	Grade III
Stage A	Preulcerative or postulcerative lesion completely epithelialized	Superficial wound, not involving tendon, capsule or bone	Wound pentrating to tendon or capsule	Wound penetrating bone or joint
Stage B	Infection	Infection	Infection	Infection
Stage C	Ischemia	Ischemia	Ischemia	Ischemia
Stage D	Infection and Ischemia	Infection and Ischemia	Infection and Ischemia	Infection and Ischemia

Table 1: The University of Texas Wound Classification System.

Figure 4: Putrid superinfected plantar ulceration with visible infected bones (University of Texas wound classification IIIb, Sanders II and III). This patient admitted himself at night to our clinic because amputation of the foot was planned in another hospital. At admission he showed a phlegmon of the foot and high elevated infection parameters.

CN of the foot had been diagnosed 7 years ago due to alcohol abuse without diabetes mellitus. The foot could be saved in a three stage surgical treatment with additional antibiotic treatment. Initially we performed thorough debridement, parenteral antibiotic treatment over 4 weeks and use of antibiotic chains and offloading immediately after admission. After 6 days we performed second-look operation with again thorough debridement, removal of antibiotic chains, resection of exocytosis because of persisting secretion and clinical signs of infection. After consolidation of the infection foot reconstruction was performed using a Hoffmann-II-Fixateur externe with another 6 weeks of off-loading till complete removal of the fixator and supply with an AFO with full weight bearing. He showed multiple reoccurrences of ulcerations over the years but he was able to walk in a customized AFO outside until his death 4 years after the demonstrated infection.

If there are clinical signs for bacteremia or sepsis at admission, surgery should be performed immediately. Surgical debridement still is the only recommended treatment for osteomyelitis [14-16]. We suggest radical debridement of all bradytrophic soft-tissue, altered tendons, and of course infected bone. Deep samples should be taken from different tissue area and a calculated antibiotic treatment should be started after taking samples. We propose a regiment of antibiotics including a beta-lactam antibiotics combined with either clindamycin or a chinolon to target the most likely bacteria (*S. aureus*), which often is combined with anaerobic bacteria or *P. aeruginosa* [11]. As soon as possible, the antibiotic treatment should be adapted to the incoming sensitivity testing [17]. A generous indication for second look operations or an open wound treatment in cases of deep infection is justified in our opinion, if there is still secretion, persisting inflammation parameters or lack of clinical signs of wound healing after 5-7 days. The goal is to eradicate remained infected tissue or regrown colonies of bacteria by repeated debridement and to shorten time of healing to mobilize patients as soon as possible. Due to polyneuropathy debridement often can be performed in local or even without anesthesia.

If open wound care is performed, for example if a wedge resection in the Brunner technique is performed, the wound dressings could be combined with local antiseptic or antibiotic treatment for example gentamicin (Figure 5). This represents an off-label use which has to be

discussed with the patient and blood levels have to be monitored, but this method has proven out to be effective in our opinion especially in cases of renal failure when many antibiotics are contra indicated or have to be reduced. Unfortunately, clinical trials are still missing.

Antibiotic treatment should be performed until the wound/ulceration is healed; at least 4 weeks or longer in our opinion. There are recommendations for antibiotic treatment up to 40 weeks in patients with diabetes mellitus [17]. We do not practice long-term antibiotic treatment for more than 6-10 weeks. If the wound and infection parameters have not healed by that time (e.g. persisting secretion), we would indicate a revision surgery. In conjunction with the surgical treatment (the most important part in our concept) and the antibiotic treatment, the patient should be examined by a diabetologist and the glucose level of the blood should be adjusted carefully. One must remember that during an infection, the glucose level is elevated and when the infection is treated successfully a rapid decrease of the blood glucose level can take place which carries the risk for hypoglycemia.

Circulation has a tremendous impact on wound healing. It should be checked at admission and if there are signs of impairment, the patient should be seen by an angiologist to improve the blood flow as soon as possible. Time of immobilization and off-loading has been kept as short as possible and has to be individually adapted to patient´s local and general condition: We immobilized the patients in the first days after surgery but remobilize them as soon as practical to minimize the complication rate in a high-risk patient population. Special postoperative footwear can be used. In cases of deep infection or phlegmon, patients need to offload until the infection is controlled. That is another reason for early second look operations: If these high-risk patients stay in bed too long, complications are common. If reconstruction surgery has to be performed using a fixateur externe, especially in unstable situations, patients need to offload 6-8 weeks. After removal of the fixateur an AFO is supplied for another 11 months with full weight bearing. Then customized orthopedic shoe are supplied [2]. Due to polyneuropathy most patients are not able to offload or perform partial loadbearing. This fact has to be considered. If only exostosis have to be removed patients only need to offload until wound healing. Sometimes a customized AFO is necessary in unstable situations. Patients with ischemia should be mobilized with load bearing as soon as possible to increase the troubled blood flow. Reopening of blood vessels is in these cases the key to success. In all cases, patient education must accompany all treatments.

Major Amputations should be avoided whenever possible. Depending on the location and the severity of the infection (in combination with the patient´s actual and general condition) there are many options to save the majority of the foot in many of the cases. As an example, in the case of an infection to the forefoot and/or the toe, Brunner´s technique for open wedge resection could be performed [18] (Figure 5). As early as possible a radical wedged incision of the forefoot with excision of the toe and the infected metatarsal bone up to its basis with the local infected soft-tissue is performed, followed by an open wound care and mild compression of the wedge by bandages. We add antibiotic treatment in the manner mentioned above and if necessary repetitive debridement. After healing, the patient still has a nearly normal foot that is easy to supply with orthopedic shoes and to walk on.

In cases of infections of the hind foot and calcaneus, a partial or total calcanectomy with open wound care, if necessary, can save the whole foot and the patient is able to walk in orthoses or even customized orthopedic shoes [19].

In addition to the well-known partial amputation techniques "internal" amputation can be performed [20, 21]. Only the infected parts of the fore and mid-foot are amputated and the non-infected bones are left.

Figure 5: Granulation of a healing wound after Brunner´s technique for open wedge dissection.

Conclusion

Infections of Charcot feet are a common problem now and will continue to be in the future in large part due to the prevalence of diabetes worldwide. CN and polyneuropathy due to other disease must not be overlooked. Especially the early stages of CN have to be diagnosed. Treatment must begin with a complete diagnostic of the whole patient and all complications, especially circulation and renal impairment, must be identified and improved. It is very important that acute stages of Charcot feet are identified and clearly discriminated from infections. Infections have to examined and classified to make treatment decisions. Hammer toes and claw toes even with very small or healed ulcerations should be seen as gate for bacteria and should be debrided and arthrodesis should be performed. Deep infections and instable situations represent a clear indication for surgery. Then thorough surgical debridement should be performed. In addition to surgery, deep tissue samples should be taken and antibiotic treatment should be performed for at least four weeks according to the sensitivity testing. Major amputations should be avoided but, if necessary, partial or internal amputations, e.g. wedge resection in Brunner´s technique, should be performed. Second look operations should be considered whenever clinical signs of infection locally and even more systemically remain after 5-7 days. Often debridement can be performed even without anesthesia due to polyneurophathy. This decision has to be made individually.

It is important to remember that successful surgery is not the end but rather the beginning of the treatment of Charcot arthropathy of the foot. Close interdisciplinary interaction of orthpaedic surgeons, angiologist, microbiologists, if necessary diabetologist or rheumatologists are necessary from the beginning of the treatment on. For treatment success, the life-long care and education of the patient and supplying them with orthopedic shoes or orthoses is obligate.

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