

Original research

Salient features and outcomes of Charcot foot – An often-overlooked diabetic complication: A 17-year-experience at a diabetic center in Bangkok



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ABSTRACT

Background: Charcot foot is a rare but a serious diabetic condition. Recognition of this often overlooked condition to provide timely and proper management is important for a better prognosis. Limited data on Charcot foot was available in Asians.

Aims: The aim of this study is to describe salient features and outcomes of Charcot foot in Thai patients.

Method: We presented our experience of 40 cases of Charcot foot patients who were treated from 2000 to 2016 at Theptarin Hospital, Bangkok, Thailand.

Results: A total of 40 Charcot foot patients were identified (13 acute, 27 chronic; mean age 58.7 ± 10.2 years; duration of diabetes 18.0 ± 8.8 years; T2DM 95%). The average serum HbA_{1c} level was $9.2 \pm 1.9\%$. While acute Charcot foot was frequently misdiagnosed as cellulitis in almost one-third of patients, osteomyelitis was a leading cause of misdiagnosis in 15% of chronic Charcot foot patients. Ulcer-free rate at 6 and 12 months were observed in 60% and 58% of patients, respectively. The mortality rate was 13% during a median follow-up period of 57 months. Only 61% of the patients resumed walking normally while almost one-fourth of them were wheelchair-bound.

Conclusions: Charcot foot in Thai patients mainly developed in long-standing poorly controlled type 2 diabetes with neuropathy, and presented late in the course of the disease. It was often misdiagnosed resulting in improper management and poor outcome which included amputation.

Introduction

Charcot foot is a rare disease but a serious complication of diabetes that occurs in patients with diabetic neuropathy [1–3]. Previous data from Western countries showed that this condition affected only 1% of patients with neuropathy but was an independent risk factor for mortality after controlling for foot ulcer and other co-morbidities [4]. Correct diagnosis of Charcot foot was important to prevent a 10 time-higher risk of amputation in these patients [5]. Unfortunately, this condition was frequently misdiagnosed resulting in a delay of appropriate treatment and poor outcome [6,7].

Misdiagnosis of Charcot foot in its early state when a patient's foot demonstrated changes typically of inflammation in the neuropathic foot often led to a deformed foot from continued weight bearing [8,9]. Limited data on Charcot foot was available in Asians. Therefore, the aim of this study was to determine clinical characteristics and outcomes of diabetic Charcot foot treated at Theptarin hospital which is one of

the largest comprehensive diabetes centers in Thailand [10]. It is also aimed to create awareness of this often overlooked condition among practicing physicians.

Subjects and methods

We conducted a retrospective study of all patients with diabetes with Charcot foot who were treated from July 2000 to June 2016 at Theptarin hospital, Bangkok, Thailand. Demographic data, previous history of diabetic foot ulcer in the previous 12 months prior to the onset of Charcot foot, chronic diabetic complications, other co-morbidities during the study period, clinical characteristics of the foot lesion, serum glycosylated hemoglobin (HbA_{1c}) level at the initial presentation, serum creatinine, and outcomes of Charcot foot were retrieved from medical records. In the absence of these data in the patient records, telephone contact was made by a foot specialist and/or diabetic nurse educators.

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Acute Charcot foot was defined by the presence of a hot swollen foot with or without erythema of the overlying skin after the exclusion of conditions resembling Charcot foot (such as cellulitis, deep vein thrombosis, gout, etc.). Chronic Charcot foot was defined as fracture or dislocation with or without gross deformity of foot in the presence of sensory neuropathy with loss of protective sensation. The diagnosis of osteomyelitis in Charcot foot, included a clinical evaluation, positive probe-to-bone test (palpable bone on inserting a blunt metal probe into a diabetic foot wound), advanced radiological imaging, and/or demonstrating positive findings on a bone specimen for both culture and histopathology. In the patients with bilateral involvement, details of each foot were retrieved and analyzed separately.

High-risk diabetic foot patients were referred to the foot clinic which was led by endocrinologists with an expertise in diabetic foot management working together with a multi-disciplinary foot care team. This retrospective study was approved by the Ethics committee of Theptarin hospital (No. 03/2016).

Statistical analysis

Continuous variables were presented as mean (\pm standard deviation) and categorical variables were presented as proportions. Comparison between an acute Charcot foot and a chronic one was done using an unpaired Student's *t*-test for continuous data and a Chi-square test for categorical data. All statistical analyses were conducted using the Statistical Package for the Social Sciences (version 17.0; SPSS, Chicago, IL, USA).

Results

During the study period, 40 patients (16 males and 24 females) were included (the mean age was 58.7 ± 10.2 years, the mean duration of diabetes 18.0 ± 8.8 years, and the median follow-up time 57.1 months (range 1–266 months). Thirty-eight patients had type 2 diabetes mellitus and two patients had type 1 diabetes mellitus. A total of 40

Charcot foot cases represented 0.5% of the total diabetic patients who attended our foot center during the study period. The mean body mass index (BMI) was 28.2 ± 5.5 kg/m² and the average serum HbA_{1c} level at baseline was $9.2 \pm 1.9\%$. Thirteen patients (41.9%) had poor glycemic control (serum HbA_{1c} level $> 8\%$ and $\leq 10\%$) and 8 (25.8%) patients had serum HbA_{1c} level $> 10\%$. The prevalence of ischemic heart disease and chronic kidney disease were 2.5% and 48.6%, respectively. Only one patient had a peripheral vascular disease. Diabetic retinopathy was present in 59.1% of the patients. Thirty-three patients (82.5%) had prior histories of foot ulcers. At presentation, Charcot foot was classified as acute in 13 patients (33%) and chronic in 27 (67%). Superimposed ulceration and osteomyelitis at the presentation of Charcot foot were common, and occurred in 48% and 13% of the patients, respectively. The details of the baseline characteristics were shown in Table 1. While acute Charcot foot was frequently misdiagnosed as cellulitis in almost one-third of patients, osteomyelitis was a leading cause of misdiagnosis in 15% of chronic Charcot foot patients. As shown in Table 2, other initial misdiagnosis included gout, ankle sprain, simple fracture, and osteoarthritis. The duration of delayed diagnosis varied from 2 to 4 months in acute Charcot foot and 2–12 months in chronic Charcot foot. One patient with chronic Charcot foot was referred for cuboid bone resection from misdiagnosis of osteomyelitis.

Interestingly, previous episodes of acute Charcot foot were reported to have occurred in almost 20% of patients, and two patients had bilateral disease at the initial presentation. Five chronic Charcot foot patients went on to develop bilateral chronic Charcot, within 9 years. According to Sanders and Frykberg's classification of Charcot foot, 50% of all episodes were localized to the tarsometatarsal joints (Lisfranc's joint) area (Pattern II). The schematic illustration of anatomical involvement of Charcot foot was demonstrated in Fig. 1. Regarding treatment, offloading and immobilization were indicated for initial treatments in both phases of the disease. As shown in Fig. 2, ulcerating chronic Charcot feet at the initial presentation was still common in our study. Initial off-loading was a total contact cast in 85.7% of acute

Table 1
Baseline characteristics of diabetic Charcot foot patients at the initial presentation.

| | Total patients (N = 40) | Acute Charcot (N = 13) | Chronic Charcot (N = 27) | p-value |
|--|-------------------------|------------------------|--------------------------|---------|
| Age (years) | 58.7 \pm 10.2 | 56.1 \pm 9.2 | 60.5 \pm 10.6 | .204 |
| Female (%) | 24 (60.0%) | 9 (69.2%) | 15 (55.6%) | |
| DM duration (years) | 18.0 \pm 8.8 | 16.6 \pm 8.3 | 16.9 \pm 9.7 | .931 |
| Type 2 diabetes (%) | 38 (95.0%) | 12 (92.3%) | 26 (96.3%) | |
| Follow-up time (months) | 80.7 \pm 74.5 | 73.2 \pm 77.4 | 86.9 \pm 77.4 | .604 |
| BMI (kg/m ²) | 28.2 \pm 5.5 | 26.8 \pm 4.8 | 29.1 \pm 5.8 | .243 |
| Serum HbA _{1c} (%NGSP)* | 9.2 \pm 1.9 | 9.1 \pm 2.3 | 9.3 \pm 1.8 | .854 |
| Serum creatinine (mg/dL)# | 1.2 \pm 0.6 | 1.0 \pm 0.2 | 1.4 \pm 0.8 | .020 |
| <i>Side of foot involvement (%)</i> | | | | |
| Right | 17 (42.5%) | 5 (38.5%) | 12 (44.4%) | |
| Left | 16 (40.0%) | 8 (61.5%) | 8 (29.6%) | |
| Both feet | 7 (17.5%) | 0(0%) | 7 (25.9%) | |
| Ex or current smoking status (%) | 6 (15.0%) | 4 (30.8%) | 2 (7.4%) | |
| <i>Comorbidities</i> | | | | |
| Myocardial infarction | 5.0% | 7.7% | 3.7% | |
| Stroke | 2.5% | 7.7% | 0.0% | |
| Peripheral vascular disease | 2.5% | 0% | 3.7% | |
| Chronic kidney disease ¹ | 48.6% | 53.8% | 45.8% | |
| Diabetic retinopathy ² | 58.8% | 61.5% | 57.1% | |
| Diabetic neuropathy | 100.0% | 100.0% | 100.0% | |
| Previous diabetic foot ulcer (%) | 33 (82.5%) | 10 (76.9%) | 23 (85.2%) | |
| Precipitating factors (recent trauma or surgery) | 35 (87.5%) | 13 (100%) | 22 (81.5%) | |
| Misdiagnosis (%) | 7 (17.5%) | 2 (15.4%) | 5 (18.5%) | |
| Concomitant osteomyelitis (%) | 5 (12.5%) | 2 (15.4%) | 3 (11.1%) | |
| Concomitant diabetic foot ulcer (%) | 19 (47.5%) | 2 (15.4%) | 17 (63.0%) | |

* Data were available in 31/40 patients.

Data were available in 33/40 patients.

¹ Data were available in 37/40 patients.

² Data were available in 34/40 patients.

Table 2
Initial misdiagnosis in 13 patients with diabetic Charcot foot.

| Diagnosis | Acute Charcot (7/13, 53.8%) | Chronic Charcot (6/27, 22.2%) |
|-----------------|--------------------------------|----------------------------------|
| Cellulitis | 4 | – |
| Osteomyelitis | 1 | 4 |
| Gout | 1 | – |
| Ankle sprain | 1 | – |
| Simple fracture | – | 1 |
| Osteoarthritis | – | 1 |

Charcot patients and 34.6% of chronic Charcot patients. Other choices of initial off-loading included felt foam dressing, short leg cast with crutch, removable cast, and special custom-made shoes. The median duration of off-loading was 3 months (range 1–8 months) in acute Charcot foot and 10 months (range 1–122 months) in chronic Charcot foot. Oral bisphosphonate was given in 3 (21.4%) patients with acute Charcot foot and the outcome was not different from those who did not receive the drug in terms of resolution from clinical inflammation and decreased in erythrocyte sedimentation rate (ESR).

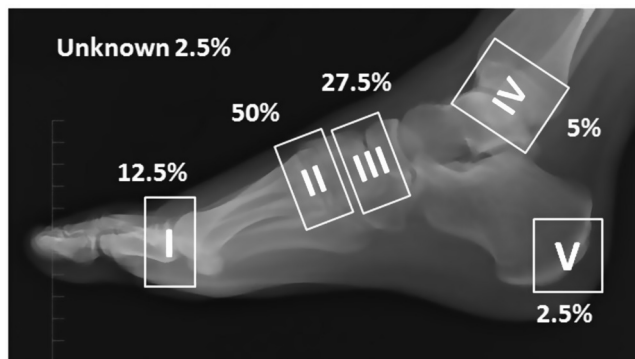
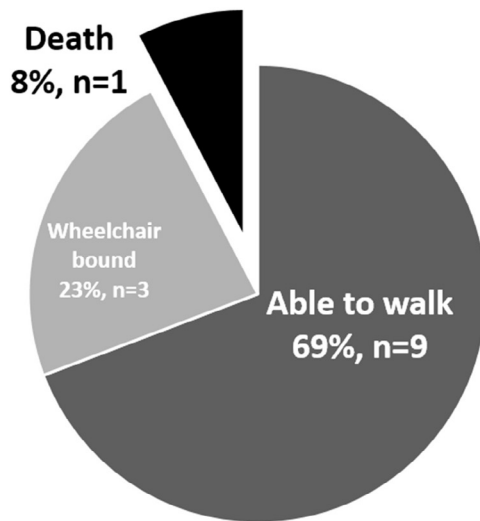
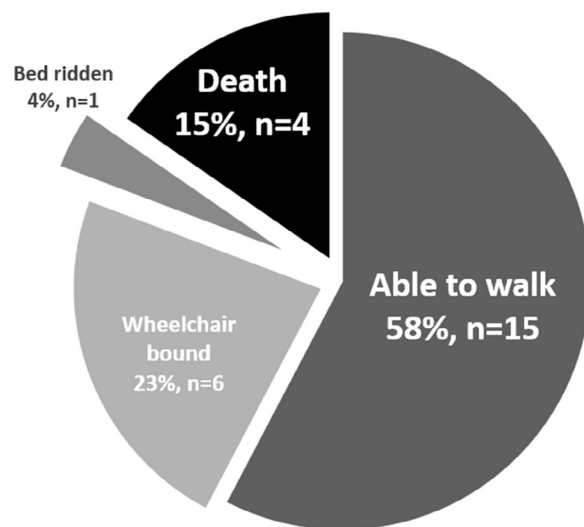


Fig. 1. Patterns of Charcot foot involvement according to Sanders and Frykberg's classification.

Surgical interventions were performed in 9 chronic phase patients. Four patients had exostectomies, and external fixation, internal fixation, arthrodesis was performed in each. Two patients needed major amputations.



Fig. 2. A) The typical appearance of a late stage of diabetic Charcot foot complicated by plantar mid-foot ulceration. B) Plain radiographs showing typical bony changes in Charcot foot (mid-foot collapse, joint fragmentation, and dislocation). C) Total contact cast was applied in this patient to offloading and preventing further bone destructions D) Plantar ulcer was healed by total contact cast for 2 months.

A) Outcomes of Acute Charcot (N=13)**B) Outcomes of Chronic Charcot (N=26)**

the median time to resolve of acute phase was 5 months (range 2-10 months)

Fig. 3. Current Functional Status of diabetic Charcot foot patients (N = 39 cases).

Follow-up data were available on 39 patients (97.5%). The acute Charcot foot resolved with a median time of 5 months (range 2–10 months). Overall, five patients died within 5 years, giving a 5-year mortality of 13%. The cause of death included 2 patients from end-stage renal disease, 1 from ischemic heart disease, 1 from hemorrhagic stroke, and 1 from sepsis. At the time of study (median follow-up period was 57.1 months after the onset of Charcot), only 61% of patients resumed walking normally while almost one fourth of patients were wheelchair-bound. Current statuses of available follow-up data in the present study were summarized in Fig. 3.

Discussion

Charcot neuroarthropathy is one of the most devastating conditions of diabetes. It was named after a French neurologist Jean-Martin Charcot who first described the condition in 1881 [11]. However, nowadays, the diagnosis of Charcot foot is still delayed or missed in as many as 25% of patients because it is not widely recognized [12–14]. A recent survey in an U.S. academic institute found that only one-third of clinicians were aware of Charcot foot [15].

In this study, Charcot foot occurred mostly in poorly controlled and long-standing patients with type 2 diabetes with neuropathy. In our patients, diabetic nephropathy and diabetic retinopathy were observed 48.6% and 59.1%, respectively. The majority (82.5%) had prior history of foot ulcers. The presentation of acute Charcot foot was inflammation of foot with or without erythema of the overlying skin. Chronic Charcot foot presented with fracture or dislocation with or without gross deformity of foot with loss of sensation. Bone involvement in about half of all episodes were localized to the tarsometatarsal joints (Lisfranc's joint) area. Superimposed ulceration and osteomyelitis at presentation of Charcot foot were common, and occurred in 48% and 13% of the patients, respectively. The diagnosis of osteomyelitis in Charcot foot was proven by a positive probe-to-bone test, radiological imaging, and/or demonstrating positive findings on a bone specimen for both culture and histopathology. Bilateral involvement was found in 20 percent of our patients. In our study, the diagnosis of Charcot foot was often delayed for 2–4 months in acute phase and 2–12 months in chronic phase.

Acute Charcot foot was frequently misdiagnosed as cellulitis while osteomyelitis was the case in chronic Charcot foot. Other misdiagnosis included gout, ankle sprain, simple fracture, and osteoarthritis. Diagnosis of acute Charcot foot was largely relied on clinical recognition. Therefore, clinicians must have a high index of suspicion for neuropathic patients presenting with early stage of Charcot foot. Inflammation was the earliest finding while rocker bottom deformity was a late finding.

The goal in the treatment of a Charcot foot is to maintain foot stability, minimizing the risk of callus, ulceration, infection, and amputation. A recent study showed that the presence of ulcer in Charcot foot increased the risk of major amputation more than 6 times when compared with Charcot foot without ulcer [16]. The gold standard of treatment remains immobilization in a total contact cast. Offloading methods have been the mainstay for the treatment of Charcot for decades. The cast for acute Charcot foot is commonly required for at least 3–6 months and then continue until signs of inflammation from clinical, radiographic, and dermal thermometric of quiescence subsided [17]. In some cases, surgery might be required as a preventive measure for development of future ulcers from foot deformities [18]. The goal of reconstruction is to create a stable foot that can be fit into the appropriate footwear. Modern internal and external fixation greatly assisted the stability of Charcot reconstruction techniques. In the latest series of more than 200 patients who underwent corrective surgeries, the clinical outcomes were favorable in valgus deformity pattern more than varus deformity pattern. Therefore, pattern of deformities seemed to be a predictive factor of clinical outcomes and patients should be informed about realistic outcome expectations [19]. Apart from reconstructive surgery, exostectomy can be useful for a plantar prominence not amenable to offloading [20]. Arthrodesis can be useful for instability, pain or recurrent ulcers [21]. Physical therapy and special custom-made shoes supported recovery. Patient education and lifelong professional foot care and surveillance are integral aspects of lifelong foot protection.

Current evidence of adjunctive therapies such as bisphosphonates or calcitonin in acute Charcot foot was inconclusive [22,23]. Our understanding of the pathogenesis of Charcot foot had increased

especially on the role of inflammatory cytokines in recruiting osteoclasts at the acute phase of development. Moreover, receptor activation of nuclear factor-kappa B ligand/osteoprotegerin (RANKL/OPG) pathway was identified as a potential novel molecular therapeutic treatment in the acute phase [24–26].

Regarding outcome of our patients, ulcer-free rate at 6 and 12 months was achieved in 60% and 58% of patients, respectively. Mortality rate was 13% during a median follow-up period of 57 months. The causes of death were end stage renal disease, cardiovascular disease and sepsis. Only 61% of patients resumed walking normally while almost one-fourth of patients were wheelchair-bound.

The epidemiology of Charcot foot varied greatly ranging from 0.1% to as high as 13% in specialized foot clinics [27,28]. The incidence of Charcot foot appeared to be higher if advanced imaging study was used for investigation [29]. There was a paucity of information on Charcot foot in Asian population [30–32]. In the present study, we confirmed that the prevalence of Charcot foot was very low (only 0.5% of the total diabetic patients who attended our foot center during the study period) even in a specialized foot clinic. This might reflect a lower prevalence of this condition in Asian population. However, recurrence of disease in the contralateral foot was higher (20%) than in Western literature (10%) [2]. Moreover, in contrast to other reports which found higher prevalence of Charcot foot in type 1 diabetes [33–37], the disease mainly developed in Thai patients with long-standing type 2 diabetes (even though this observation would be explained by much lower prevalence of type 1 diabetes in Thailand when compared with Western countries). Various classification systems had been developed to classify Charcot foot. Eichenholtz classification [38] which was described since 1966 was commonly used based on only findings from plain X-rays dividing Charcot foot into 3 stages (development, coalescence and reconstitution). However, more recent study argued that magnetic resonance imaging (MRI) was more sensitive than X-rays in detecting foot deformities [39]. MRI can detect bone marrow edema so it is more sensitive and specific than X-rays in the detection of Charcot earliest stage (stage 0 Charcot foot) and an MRI-based classification was proposed [40]. In 2011, the American Diabetes Association's Charcot Task Force divided the phase of Charcot into 'active' and 'inactive' phase only [1]. Thus, we adopted this system and applied the most commonly used anatomic classification system described by Sanders and Frykberg [18]. Consistent with other series [34,37], our study showed that patterns 2 (the tarsometatarsal joints or Lisfranc's joint) was the most common in approximately 60% of cases. It is, therefore, important to look carefully for signs of Charcot changes on imaging in diabetics with Lisfranc injuries [41].

To the best of our knowledge, the present study is the first comprehensive report in Southeast Asia region and showed the salient features and the long-term outcomes of diabetic Charcot foot in a comprehensive diabetic center. Recognition of this often overlooked condition to provide timely and proper management are important for a better prognosis.

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Authors' contributions

TY performed the statistical analyses, interpreted the data and drafted the manuscript. SJ and PW contributed to the statistical analyses, interpretation of the data and revised the manuscript critically before submission. KS, PS, ST, MS, NS, and HT made substantial contributions to the discussion of results. They revised the manuscript critically before submission. All authors read and approved the final manuscript.

Conflicts of interests

None.

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