Clinical factors associated with Charcot foot

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Charcot neuroarthropathy of the lower limb is a serious complication of diabetes, frequently resulting in gross deformity that is strongly associated with lower-limb amputation. In this comparative, case-controlled study, the authors sought to determine the clinical factors associated with Charcot among people with diabetes – and its incidence – at a large diabetes treatment centre in Jordan. Diabetes duration was found to be significantly longer among cases of Charcot than controls, and glycaemic control was found to be significantly better among controls than cases – whether measured by HbA_{1c} level or fasting plasma glucose. The incidence of Charcot in the study population was found to be 1.9 cases/1000 people with diabetes.

Article points

1. Charcot neuroarthropathy frequently leads to lower-limb deformity, which may dispose people to limb-threatening ulceration.
2. The authors sought to determine clinical factors that were associated with Charcot in a Jordanian population with diabetes.
3. Polyneuropathy, longer diabetes duration and poorer glycaemic control were significantly associated with Charcot in this cohort.
4. The clinical factors linked to Charcot in the present study were consistent with those reported elsewhere.

Keywords

- Charcot foot
- Deformity
- Polyneuropathy

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Diabetic peripheral polyneuropathy disposes people to repetitive micro- and macrotrauma to the joints and periarticular soft tissues of the foot and ankle. These processes are thought in some cases to trigger the bone and joint fragmentation and destruction typical of Charcot neuroarthropathy (Charcot foot; *Figure 1*; Frykberg et al, 2000). As the incidence of diabetes has risen worldwide, it is now the most common cause of Charcot (International Diabetes Federation, 2005).

Charcot processes may arise within days of a minor traumatic event, such as tripping, or may be the product of long-term trauma from inappropriate walking patterns or heavy load bearing (i.e. concomitant obesity; Stuck et al, 2008). The usual initial symptoms of Charcot is the erythaemic swelling of the foot and pain in otherwise insensate feet, and the early detection and ongoing management of the condition can avoid or lessen foot deformity (Armstrong et al, 1997; Foltz et al, 2004). While Charcot does not pose a serious lower-limb amputation risk *per se*, ulceration resulting from altered plantar pressures associated with the grossly deformed foot that is commonly the product of Charcot process greatly increases the risk of amputation (Armstrong and Lavery, 1998; International Working Group on the Diabetic Foot, 2006; Sohn et al, 2010).

There is a lack of data describing the prevalence of Charcot foot due, in part, to missed diagnoses and variable descriptions of the condition (Wukich and Sung, 2009). Estimates range from 0.1–0.4% (Rajbhandari et al, 2002) of the population with diabetes. In one study published in 1972 (Sinha et al), 101 cases of Charcot were found among 68 000 people with diabetes, while more recently Fabrin et al (2000) found

the incidence to be one case per 333 people with diabetes – suggesting an increase in the incidence of Charcot that is consistent with the increasing prevalence of diabetes (Ajlouni et al, 2008).

The purpose of the present study was to determine the clinical factors associated with Charcot, and its incidence, among people with diabetes being treated at the the National Center for Diabetes, Endocrinology and Genetics (NCDEG), Amman, Jordan.

Methods

In this comparative, case-controlled study, people with diabetes and a Charcot diagnosis attending the NCDEG Foot Clinic were invited to participate. A diagnosis of Charcot foot was made on the basis of X-ray findings, clinical symptoms and signs consistent with Charcot neuroarthropathy. People with diabetes attending the NCDEG Foot Clinic for non-Charcot complications were invited to participate as controls.

Demographic data and medical histories were taken from participants, including age, sex, weight, height, duration of diabetes, antidiabetes regimen, ambulatory status, smoking habit and employment status. The last three HbA_{1c}, fasting plasma glucose, triglyceride and total, HDL- and LDL-cholesterol results for each participant were recorded. Previous diagnoses of hypertension or retinopathy were also recorded.

Assessment of the participants' feet was undertaken. Lower limb ischaemia was defined as the absence of posterior tibial artery pulse with or without symptoms and signs of peripheral arterial disease (PVD; PVD symptoms and signs comprise: intermittent claudication, oedema, mottled skin, loss of hair, cold feet, cyanotic feet), or the absence of dorsalis pedis pulses with at least one symptom or sign of PVD. Neurological assessment of the feet sought to detect the loss of protective sensation (10-g monofilament) and vibratory sensation (tuning fork). The presence of painful neuropathy was determined by interview. Clincial assessment was conducted to detect the presence of callus, anhidrosis (dry skin), fissures, tinea pedis, active ulceration, corns, dermopathy, cellulitis, oedema or amputation at enrolment.

This study was approved by the NCDEG Ethics Committee. Data were used only for scientific reporting and confidentiality was maintained. Participation was optional and data were collected only after informed consent was obtained from participants.

Statistical analysis

Statistical analysis was carried out SPSS (version 16; SPSS, Chicago, IL). Data were examined for data entry errors and outlier values. The relationships between Charcot and a number of variables were assessed for statistical significance using bi-variant analysis (Chi square) for categorical variables.

Results

During the 3-month study period (1 November 2009–1 February 2010), 10 642 people with diabetes attended the NCDEG, 430 of whom were referred to the Foot Clinic and 20 of those referred were found to have Charcot (incidence, 1.9/1000 people with diabetes). Half of the cases of Charcot occurred in the right foot, half in the left, with nine being located in the midfoot and 11 in the hindfoot. The majority of Charcot cases were in the chronic phase (12/20, 60%), with the remainder being subacute (5/20, 25%) or acute (3/20, 15%).

Ninty-two people (47 men; 45 women) with diabetes but without Charcot who were referred to the NCDEG Foot Clinic were

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3. During the 3-month study period, 10 642 people with diabetes attended the National Center for Diabetes, Endocrinology and Genetics, 430 of whom were referred to the Foot Clinic and 20 of those referred were found to have Charcot.
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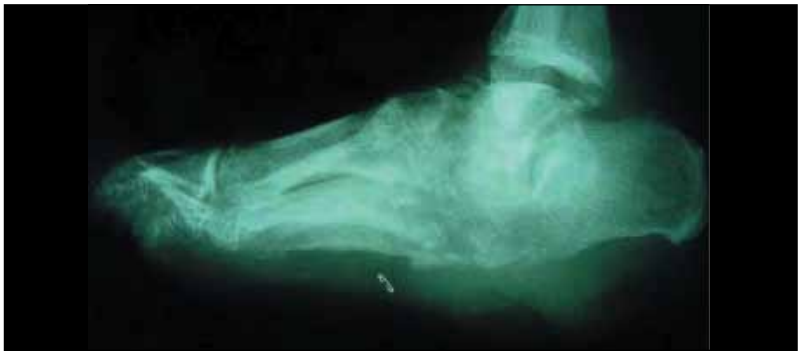

Figure 1. An X-ray of a Charcot foot. Note the collapse and destruction of the bones of the mid-foot, resulting in the classic "rocker-bottom" sole.

recruited as controls, and all 20 (9 men; 11 women) Charcot cases were enrolled. Participant demographics are shown in *Table 1*.

Table 1. Participant demographics. Cases had diagnosed Charcot foot, while controls did not.

Variable	Controls	Cases	*P* value
Sex *n* (%)			0.622
Men	47.0 (51.1)	9.0 (45.0)	
Women	45.0 (48.9)	11.0 (55.0)	
Age years (SD)	60.0 (9.4)	58.5 (8.9)	0.423
BMI kg/m^2 (SD)	30.2 (5.4)	33.5 (8.8)	0.121
Diabetes duration (mean years)	13.4	23.0	0.015*
Glycaemia mean (SD)			
HbA_{1c} %	7.8† (1.04)	8.9‡ (1.1)	0.001*
Fasting blood glucose mg/dL	163.0 (47.4)	190.0 (41.3)	0.050*
Lipid profiles mg/dL (SD)			
Total cholesterol	168.0 (32.2)	173.0 (38.1)	0.571
Triglyceride	156.0 (73.6)	181.0 (96.4)	0.239
LDL-cholesterol	100.0 (26.5)	103.0 (31.3)	0.653
HDL-cholesterol	51.4 (35.6)	44.5 (18.4)	0.239
Employment status *n* (%)			0.486
Employed	20.0 (21.7)	3.0 (15.0)	
Unemployed	72.0 (78.3)	17 (85.0)	
Smoking status†† *n* (%)			0.123
Non-smoker	55.0 (59.8)	9.0 (45.0)	
Past smoker	26.0 (28.3)	6.0 (30.0)	
Current smoker	11.0 (12.0)	5.0 (25.0)	
Antidiabetes treatment *n* (%)			<0.005*
Diet	2.0 (2.2)	0.0 (0.0)	
Oral agents	36.0 (39.1)	0.0 (0.0)	
Insulin	2.0 (2.2)	7.0 (35.0)	
Oral agents and insulin	52.0 (56.5)	13.0 (65.0)	
Diabetic complications *n* (%)			
Retinopathy	22.0 (23.9)	15.0 (75.0)	<0.005*
Hypertension	68.0 (73.9)	17.0 (85.0)	0.273

*Statistically significant. †62 mmol/mol; ‡74 mmol/mol. SD, standard deviation. ††According to World Health Organization guidelines (WHO, 1998): past smoker, smoked >100 cigarette in their lifetime; current smoker, regular smoking of ≥1 cigarette/day for ≥1 month continuously; non-smoker, never smoked in their lifetime.

There was no significant difference in the sex, age, BMI, hypertension, lipid profiles or employment or smoking status distribution between the cases and controls. Diabetes duration was significantly longer among cases (mean 23 years) than controls (mean 13.4 years; P=0.015), and participants with Charcot were significantly more likely to be on a more intensive antidiabetes regimen than controls (P<0.005). Mean glycaemic control was significantly better among controls than cases – whether measured by HbA_{1c} level (7.8% [62 mmol/mol] vs 8.9% [74 mmol/mol]; P=0.001) or fasting plasma glucose (163.0 mg/dL vs 190.0 mg/dL; P=0.050). Participants with Charcot were significantly more likely to have a concurrent diagnosis of diabetic retinopathy than controls (P<0.005).

Differences in the frequency of foot-associated pathologies between cases and controls are shown in *Table 2*. Participants with Charcot were significantly more likely to have peripheral neuropathy diagnosed by either loss of vibration or protective sensation than controls (both P<0.005). There was no difference between the two groups with regard to the frequency of vascular insufficiency. Participants with Charcot were significantly more likely to have a prior lower-extremity amputation, a foot ulcer, diabetic dermopathy, skin fissures, callus or anhidrosis than controls (all P≤0.020).

Discussion

Incidence of Charcot in the present study was 1.9 cases/1000 people with diabetes. This is in-line with the findings Fabrin et al (2000; 3/1000).

In the present study, participants with Charcot had a significantly longer duration of diabetes than controls, a result that confirms those reported elsewhere (Leung et al, 2009). A number of large-scale trials have shown that good glycaemic control reduces the risk of a range of diabetic complications (UK Prospective Diabetes Study Group, 1998; Holman et al, 2008). In the present study, blood glucose levels were significantly higher

Page points

1. Charcot was strongly associated with peripheral neuropathy – the loss of both protective and vibration sensation – in the present cohort.
2. No positive correlation between Charcot and peripheral vascular insufficiency was identified in the present cohort.
3. To the authors' knowledge, there has been no previous study of the incidence of diabetic Charcot foot, and its associations with clinical factors, in a Jordanian population.

among those with Charcot (mean HbA_{1c} level 8.9% [74 mmol/mol]), which agrees with the findings of Fabrin et al (2000) who reported that the median HbA_{1c} level among people with Charcot in their cohort was elevated at 9.4% (79 mmol/mol).

As was to be expected, Charcot was strongly associated with peripheral neuropathy – the loss of both protective and vibration sensation – in the present cohort, as has been shown elsewhere (Rosenblum et al, 1997; Leung et al, 2009). Dermopathy, skin fissure, anhidrosis and callus were all significantly associated with Charcot in the present cohort; these conditions have previously been associated with diabetic peripheral polyneuropathy and their high correlation with Charcot are, therefore, to be expected (Bristow, 2008).

Amputation and ulceration were significantly associated with Charcot in the present cohort – which is consistent with reports from Lavery et al (2003) and Sohn et al (2010) – and confirms the increased risk of ulceration secondary to foot deformity among people with Charcot. Charcot processes in the present cohort tended to affect the hindfoot more than midfoot joints. However, Leung et al (2009) and Pakarinen et al (2002) report Charcot affecting the midfoot joints more commonly.

People with Charcot in the present study were significantly more likely to have retinopathy than controls, a finding that is likely related to the longer duration of diabetes and the poorer glycaemic control among the cases compared with controls. Similarly, Foltz et al (2004) and Pakarinen et al (2009) both found retinopathy to be significantly associated with Charcot in their cohorts.

No positive correlation between Charcot and peripheral vascular insufficiency was identified in the present cohort. Similar findings were reported by Rosenblum et al (1997), Foltz et al (2004) and Leung et al (2009). Although previous studies used the same m ethods as used in the present study for evaluating the vascularity of the foot (palpation of the dorsalis pedis and posterior tibial pulses), these methods may be considered an insufficient test in the person with Charcot and form a limitation of our study. The reliability of clinician palpation of vessels in the Charcot foot may be compromised by gross deformity having altered normal anatomic vessel routes, or distortion due to severe oedema. Doppler technology would be a better test of vascularity in the Charcot foot.

Table 2. Differences in the frequency of foot-associated pathologies between cases and controls.

Condition *n* (%)	Controls (*n*=92)	Cases (*n*=20)	*P* value
Previous amputation	2.0 (2.2)	10.0 (50.0)	<0.005*
Dermopathy	4.0 (4.3)	6.0 (30.0)	0.020*
Cellulitis	12.0 (7.6)	2.0 (10.0)	0.709
Corn	4.0 (4.3)	2.0 (10.0)	0.311
Ulceration	6.0 (6.5)	15.0 (75.0)	<0.005*
Tinea pedia	37.0 (40.2)	12.0 (60.0)	0.107
Skin fissure	59.0 (64.1)	7.0 (35.0)	0.017*
Anhidrosis (dry skin)	90.0 (98.0)	15.0 (75.0)	<0.005*
Callus	54.0 (58.0)	18.0 (90.0)	0.017*
Retinopathy	22.0 (23.9)	15.0 (75.0)	<0.005*
Hypertension	68.0 (73.9)	17.0 (85.0)	0.273
Clinical signs of peripheral vascular insufficiency			
Palpable dorsalis pedis pulses	84.0 (91.3)	18.0 (90.0)	0.853
Palpable posterior tibial pulses	82.0 (89.13)	16.0 (80.0)	0.854
Clinical signs of peripheral neuropathy			
Peripheral neuropathic pain	24.0 (26.1)	10.0 (50.0)	0.036
Loss of vibration sensation	9.0 (9.8)	13.0 (65.0)	<0.005*
Loss of protective sensation	11.0 (12.0)	19.0 (95.0)	<0.005*

*Statistically significant.

Conclusion

To the authors' knowledge, there has been no previous study of the incidence of diabetic Charcot foot, and its associations with clinical factors, in a Jordanian population. In line with other reports, the present study found that longer diabetes duration and poor metabolic control are major risk factors for Charcot foot in this population. ■

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