Diabetic Neuropathies

including

Charcot Neuroarthropathy

PATHOPHYSIOLOGY OF DIABETIC FOOT ULCERS

The etiology of diabetic foot ulcers is multi-factorial and foot ulcers are one of the major complications for clients with diabetes. The manifestations of neuropathy, vasculopathy, immunopathy and poor glycemic control are responsible for the development of foot pathology. Peripheral arterial disease (PAD) is a component cause in approximately one-third of foot ulcers and is often a significant risk factor associated with recurrent wounds [9].

NEUROPATHY

In terms of neuropathy, the sensory component eliminates protective sensation in the foot, and the inability to determine injury or trauma. Autonomic changes cause dry skin, fissures and impaired circulation and the motor component leads to muscle atrophy, foot deformity and increased plantar pressure[2]. Neuropathy in the lower extremities and feet is mostly associated with high rates of skin breakdown and neuropathic fractures, [2]. The manifestation of neuropathies in the foot can be determined by careful evaluation of signs, symptoms and through patient interview. The neuropathies often appear together as will be shown in the pictures accompanying the descriptions

SENSORY NEUROPATHY

Sensory neuropathy is a result of the interactions of multiple factors such as glycemic control, ischemia and impaired healing and predisposes peripheral neurons, glial cells and vascular endothelial cells to damage that ultimately leads to neuronal injury and peripheral neuropathy [4]. Sensory neuropathy is further classified as being small or large fibre neuropathy.

- Small fibre neuropathy is a structural abnormality of small fibres characterized pathologically by degeneration of the distal terminations of small fibre nerve endings [3]. It is described by clients as a stabbing, burning pain, or abnormal sensation of the skin, such as tingling, cold or itchiness which contributes significantly to morbidity. Clients can experience sensations of their socks being bunched up or their shoes not fitting correctly and allodynia (allodynia can lead to the triggering of a pain response from stimuli which do not normally provoke pain). They can have an apparent paradox of numbness and exquisite sensitivity at the same time. Interestingly, which symptom predominates varies dramatically from person to person and pain is often worse at night [4].

- Large fibre neuropathy presents as painless paresthesia with impairment of vibration, joint position, touch and pressure sensations, and loss of ankle reflex [5]. It is responsible for loss of protective sensation which is associated with a seven-fold increase in risk of diabetic foot ulcer [6].

Sensory neuropathy, eliminates protective sensation in the foot client does not feel pressure, foreign object in shoe, or trauma. Without protective sensation, a person lacks the physical symptoms that would normally cue healthy individuals to examine or rest their feet, thereby increasing the extent of skin damage before presenting for treatment. The inciting trauma could be caused simply by ill-fitting shoes (always rule out the footwear as the pathology) or minor sprains and strains.

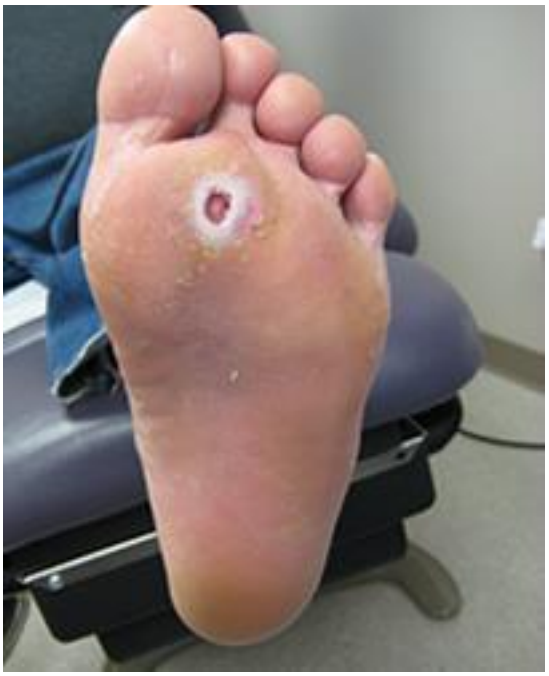

Figure 1: Wound caused by pressure from motor neuropathy (foot has lost medial arch, toes have deformity and fat pads are displaced,sensory neuropathy (wound has developed), in a setting of autonomic neuropathy (dry skin)

Figure 2: Hemmhoragic callous caused by pressure and sensory neuropathy

AUTONOMIC NEUROPATHY

Loss of sympathetic vascular innervation means that sweating is diminished or absent; as a result, the skin of the feet remains dry and has a tendency to become scaly and cracked, thereby allowing infection to penetrate below the skin[7]. The lack of autonomic tone in the capillary circulation causes shunting of blood from arteries directly into veins, bypassing the tissues that need nutrition[7]. As a result the foot feels warm with distended veins and bounding pulses. Despite these apparent signs of adequate perfusion, the foot is vulnerable to local "microvascular" gangrene, will heal very poorly and slowly, and will be less able to resist infection[8]. Autonomic neuropathy can cause the following issues:

- Aching, pulsation, tightness, cramping, and pruritus. It is also responsible for dry flaking fragile skin which increases the risk for fissuring and skin breakdown, creating potential sites of infection [2].
- Peripheral edema, which is often associated with both foot ulceration and poor wound healing

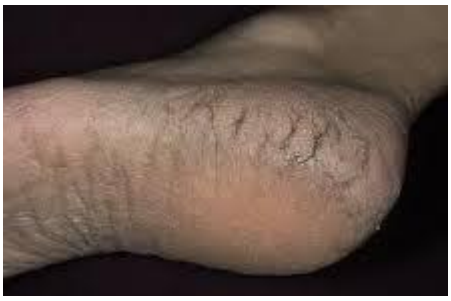

Figure 3: Autonomic Neuropathy manifested on heels

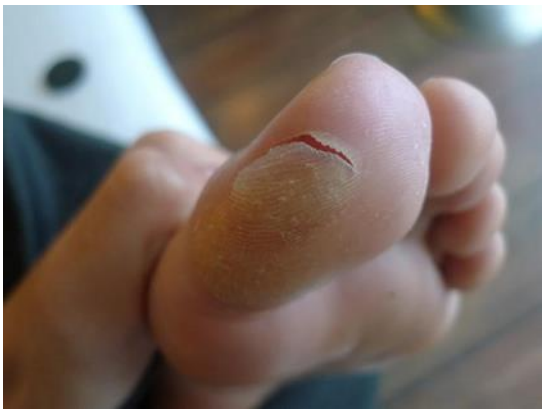

Figure 4: Autonomic Neuropathy manifested on great toe

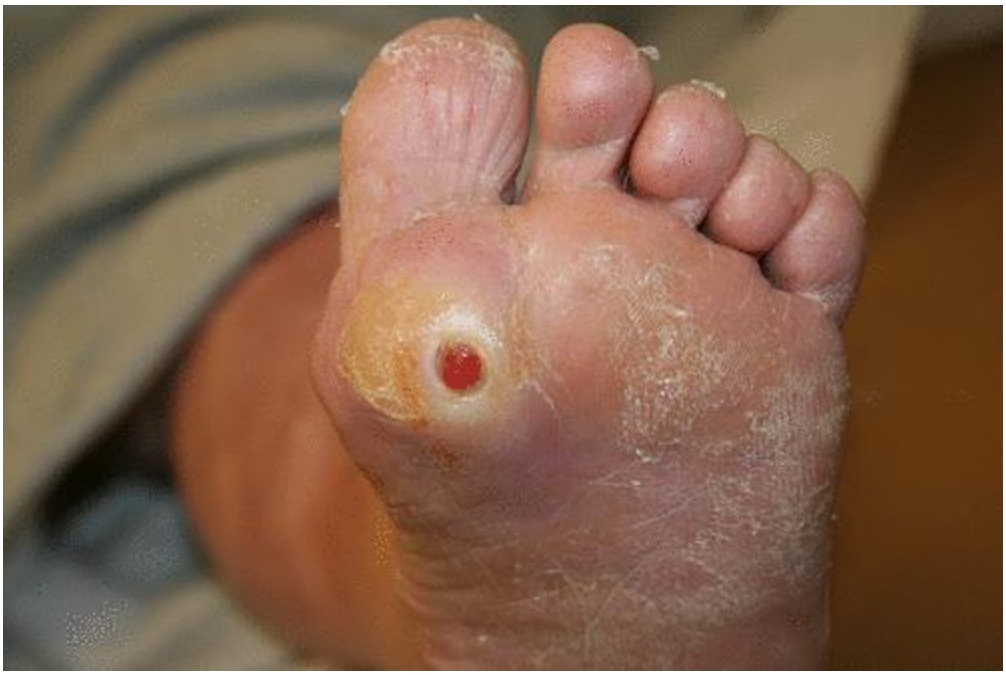

Figure 5: Autonomic Neuropathy on foot and toes, Sensory Neuropathy is part of cause of wound on 1st Metatarsal Head

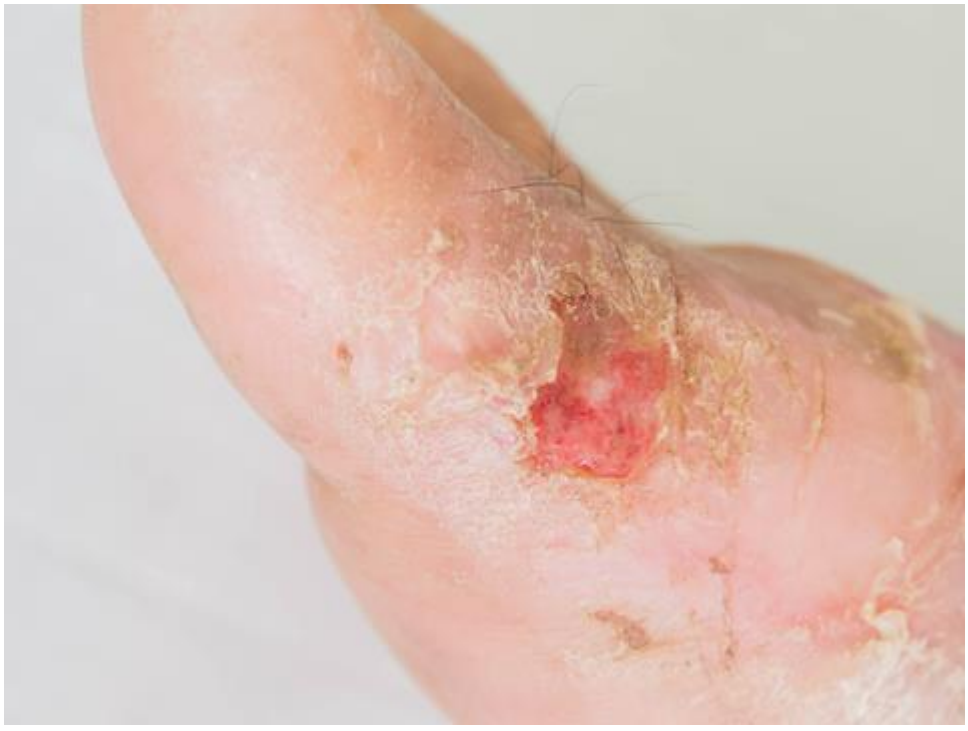

Figure 6: Autonomic Neuropathy on foot and toes.

MOTOR NEUROPATHY

Motor neuropathy affects the lumbricals and interosseous (intrinsic) muscles of the foot causing weakness and atrophy. These small muscles are responsible for the stability of the digits, integrity of the transverse arch, and plantar flexion metatarsophalangeal (MTP) joints. The delicate balance between the flexors and extensors of the toes is affected leading to the development of hammertoes, claw toes, prominent metatarsal heads, pes cavus (high arch), and displacement of the anterior fat pads [11]. As the intrinsic foot muscles lose function, the larger extrinsic leg muscles gain advantage and deform the foot in a variety of contracted positions. This muscle imbalance is called an intrinsic minus foot with many prominences that can lead to ulcerative lesions [10]. In addition, instability of the midtarsal joint and midfoot joints occur due to loss of intrinsic muscle strength.

Unfortunately, structural deformities are common sites of abnormally high pressure. Repetitive pressure at these sites can result in tissue breakdown and in calluses, and in the absence of protective sensation; continued activity can cause the calluses to thicken, hemorrhage underneath, and eventually ulcerate[12].

Motor neuropathy leads to muscle atrophy, foot deformity and increased plantar pressure. These deformities change pressure patterns on the foot making certain areas more susceptible to trauma or ulceration. Callus (hyperkeratosis) commonly encountered on the soles of feet, under the metatarsal heads and on the plantar aspect of the toes where there are areas of pressure, uneven weight distribution, and friction [1].

Figure 7: High medial arch caused by motor neuropathy

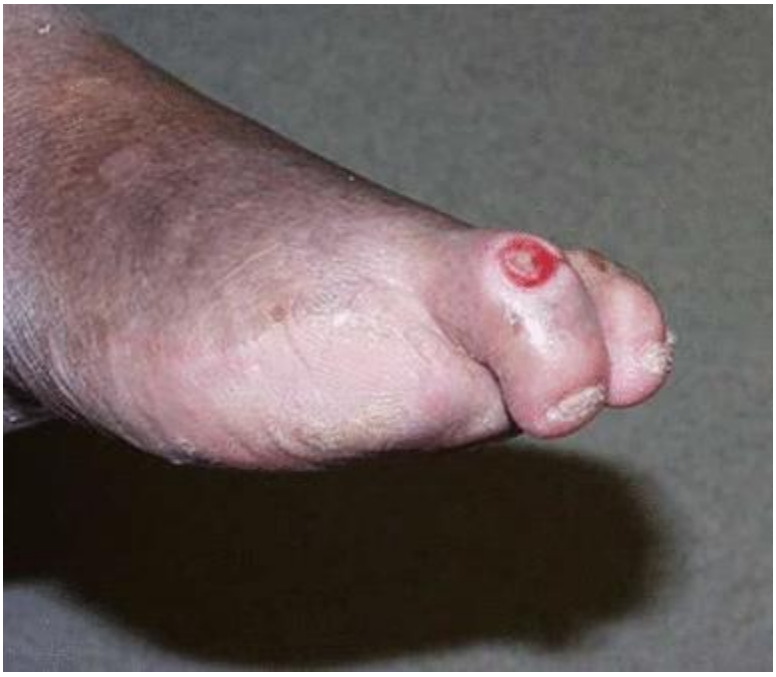

Figure 8: Neurogenic claw toes in a patient with previous toe amputations. The deformity resulted in dorsal toe ulceration secondary to trauma from shoe. Photograph courtesy of Del Core

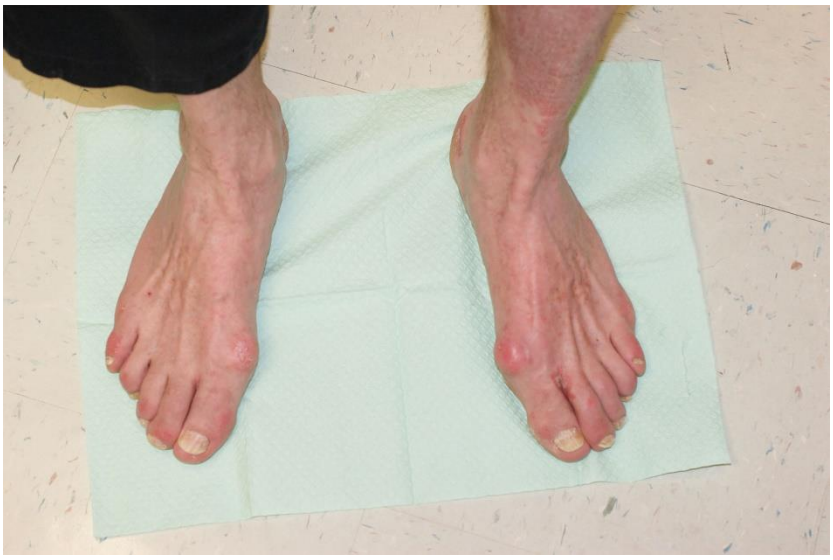

Figure 9: Image courtesy of Kevin F. Sunshein, DPM. Intrinsic minus foot, note deep channels between the metastarsals indicative of lumbrical muscle wasting from denervation

Acute Charcot Neuroarthropathy

Acute Charcot Foot (Acute Charcot Neuroarthropathy) is a rare, disabling condition which can cause widespread destruction of bone and joint architecture with loss of function. Early recognition of acute Charcot foot in a person with diabetes is a diagnostic challenge as the clinical suspicion even in high risk patients is often low, and the consequences of a missed diagnosis can be devastating [10].

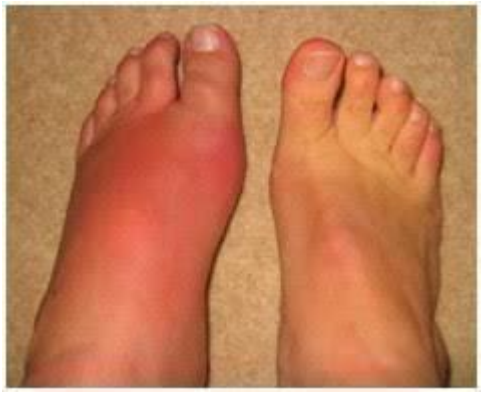

Figure 10: Acute Charcot Neuroarthropathy on left foot

The Charcot process, passes from this acute phase of development through a stage of coalescence, in which the bone fragments are reabsorbed, the edema lessens, and the foot heals, to the stage of consolidation, in which the final repair and remodeling of bone occurs [13]. The predictable pattern of untreated disease leads to collapse of the longitudinal and transverse arches resulting in a 'rocker-bottom' foot or a collapsed and destroyed ankle joint [14].

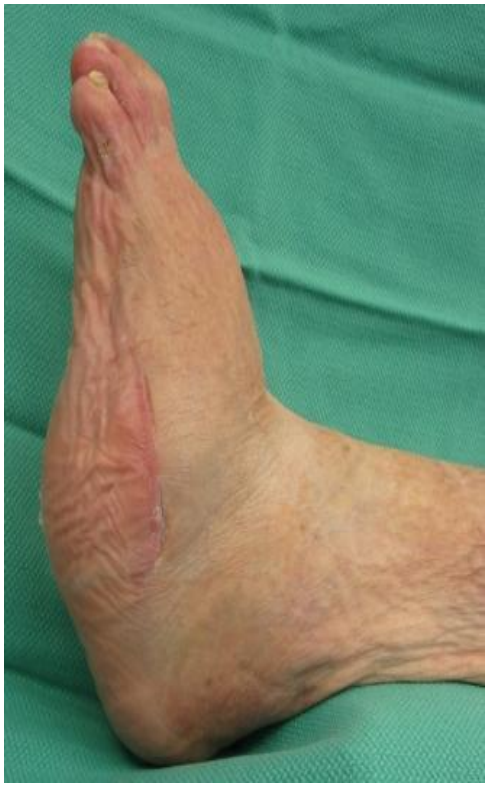

Figure 11: Collapse of the longitudinal and transverse arches resulting in a 'rocker-bottom' foot

The foot changes are induced by the triad of small muscle wasting, decreased sensation, and abnormal distribution of weight when standing. Fractures can occur either spontaneously or with minimal stress and are followed by progressive bone disorganization with an increased risk of secondary ulceration.

Diagnosis remains predominantly clinical and is based on the presence of swelling, erythema, increased skin temperature and joint effusion in an insensate joint. The presentation may be indistinguishable from that of cellulitis, gout or deep vein thrombosis. As such, most patients in fact present to emergency medical services at two to three months after the onset of symptoms. Peripheral sensory neuropathy associated with reduced sensation is the predisposing condition that permits the development of arthropathy. Pain, however, may sometimes still be a feature [15].

Patients are most commonly affected in their fifth and sixth decades and both sexes are affected almost equally, although there is a slight male predominance. Most patients have been diabetic for more than five years before the onset of the acute Charcot process. Although patients may recall a specific traumatic event which started their symptoms, very often no causative event will be identified [16]. About 25% of patients will ultimately develop similar changes in the other foot [17].

References

1. Wounds International. (2013). International best practice guidelines: Wound management in diabetic foot ulcers. Retrieved from www.woundsinternational.com

2. Del Core, M.A., Ahn, J., Lewis, R.B., Raspovic, K.M., Lalli, T.A.J., & Wukich, D.K. (2018). The evaluation and treatment of diabetic foot ulcers and diabetic foot infections. *Foot and Ankle Orthopaedics, 3*(3) https://journals.sagepub.com/toc/faoa/3/3

3. Hoeijmakers , J.G., Faber C. G., Lauria G., Merkies, I.S., & Waxman, S.C. (2012).. Small-fibre neuropathies-advances in diagnosis, pathophysiology and management. *Nature Reviews Neurology, 8,*369–379.

4. Callaghan, B. C., Cheng, H. T., Stables, C. L., Smith, A. L., & Feldman, E. L. (2012). Diabetic neuropathy: clinical manifestations and current treatments. *The Lancet. Neurology, 11*(6), 521–534. doi: 10.1016/S1474-4422(12)70065-0

5. Bansal, V., Kalita, J., & Misra, U. K. (2006). Diabetic neuropathy. *Postgraduate medical journal, 82*(964), 95–100. doi:10.1136/pgmj.2005.036137

6. Singh, N., Armstrong, D.G., & Lipsky, B.A. (2005). Preventing foot ulcers in patients with diabetes. *JAMA, 293,* 217-228.

7. Kamenov, Z.A., & Traykov, L.D. (2012) Diabetic autonomic neuropathy. *Adv. Exp. Med. Biol, 771*, 176–193.

8. American Heart Association. (2019, July 8). Microvascular disease anywhere in the body may be linked to higher risk of leg amputations. Science Daily. Retrieved July 26, 2019 from www.sciencedaily.com/releases/2019/07/190708084328.htm

9. Reiber, G.E., Vileikyte, L., Boyko, E.J., del Aguila, M., Smith, D.G., Lavery , L.A., Boulton, A.J. (1999). Causal pathways for incident lower-extremity ulcers in patients with diabetes from two settings. *Diabetes Care, 22,* 157–162.

10. Andersen, H., Gjerstad, M.D., Jakobsen, J. (2004). Atrophy of foot muscles: A measure of diabetic neuropathy. *Diabetes Care*, *27,* 2382-2385.

11. Grunfeld, C. (1992). Diabetic foot ulcers. Etiology, treatment, and prevention. *Adv Intern Med*, *37*, 103–32.

12. Veves, A., Murray, H.J., Young, M.J., Boulton, A.J. (1992). The risk of foot ulceration in diabetic patients with high foot pressure: a prospective study. *Diabetologia, 35*(7),660–3.

13. Eichenholtz, S.N. (1966). Charcot Joints, Springfield Ilinois: Thomas

14. Pakarinen, T.K., Laine, H.J., Mäenpää, H., Marilla, P. & Lahtela. (2009). Long-term outcome and quality of life in patients with Charcot foot, Foot Ankle Surgery, 15, 187-191.

15. Brodsky, J.W. (2006). The diabetic foot. In Coughlin, M.J., Mann, R.A., Saltzman, C.L. eds. Surgery of the Foot and Ankle. Eighth ed. St Louis MO: Mosby 13-41.

16. Papanas, N., & Maltezos, E. (2013). Etiology, pathophysiology and classifications of the diabetic Charcot foot. Diabetic Foot and Ankle, 4, 1-5

17. Caputo, G.M., Ulbrecht, J., Cavanageh, P.R., Juliano, P. (998). The Charcot foot in diabetes: six key points. American Family Physician, 57, 2705-2710