

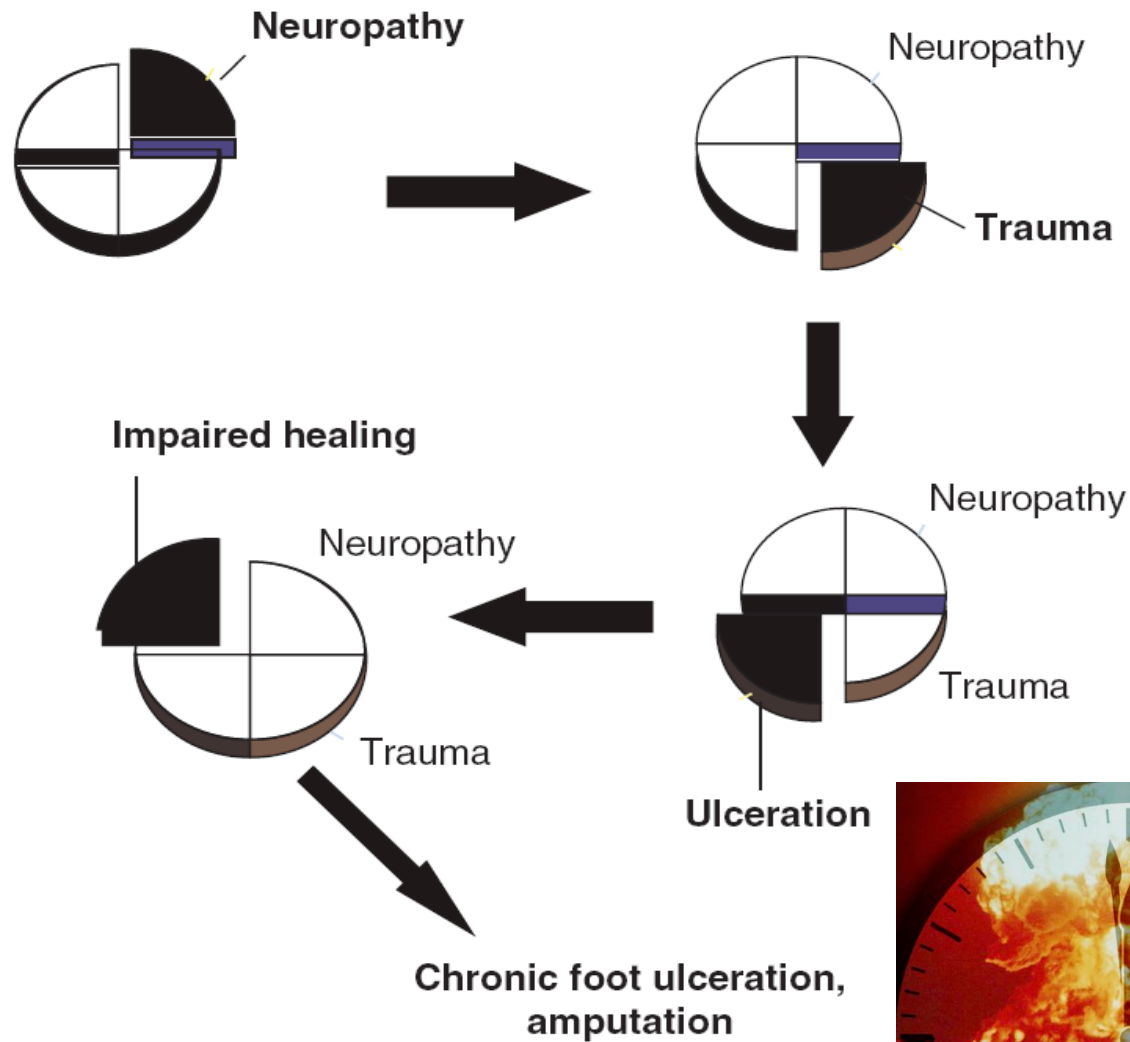
Green Starboard Light

Underneath the iceberg: pathophysiology of diabetic foot and how to kill the culprit?

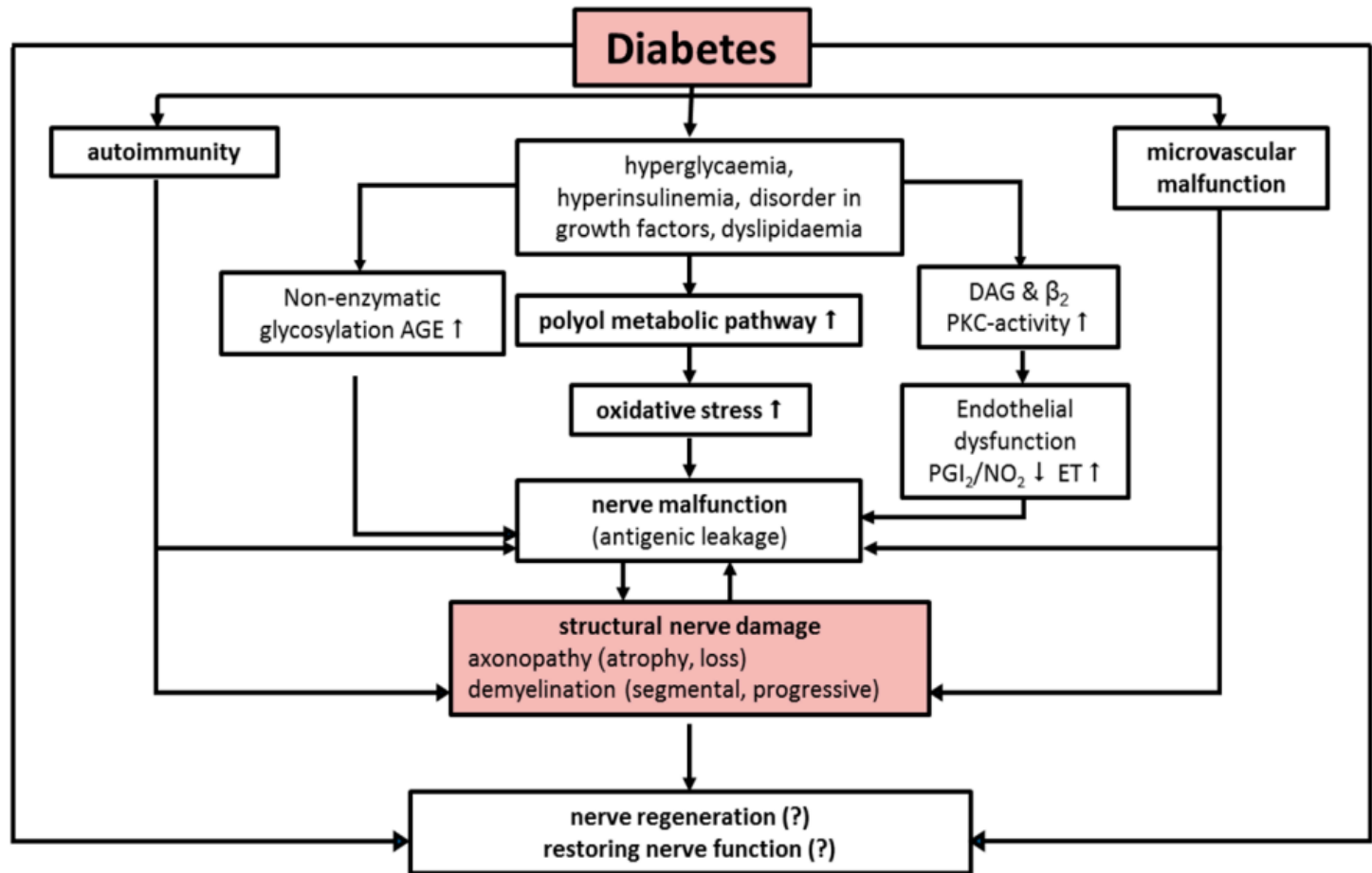


- Natapong Kosachunhanun, M.D.

# The pathway to foot ulceration.

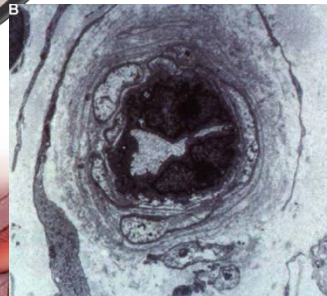
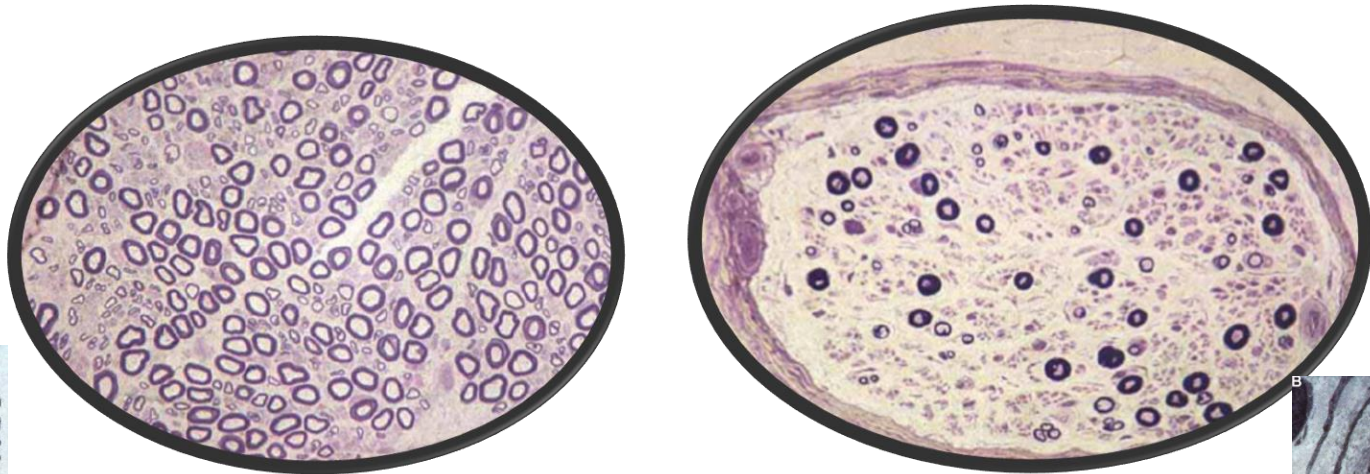


# Pathophysiology of diabetic neuropathy



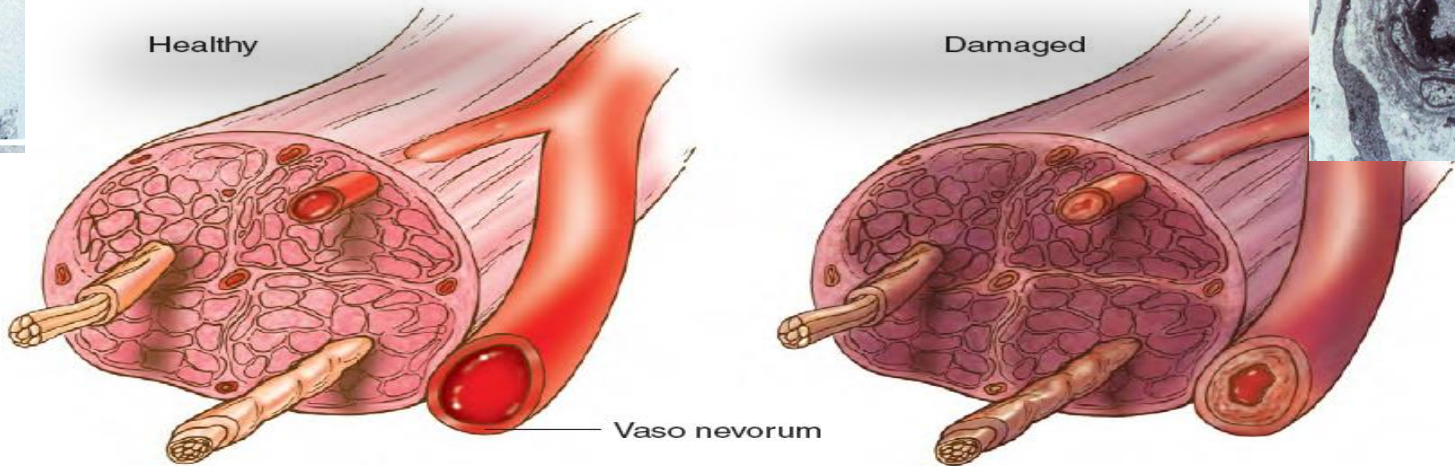


# Normal and damaged nerves.



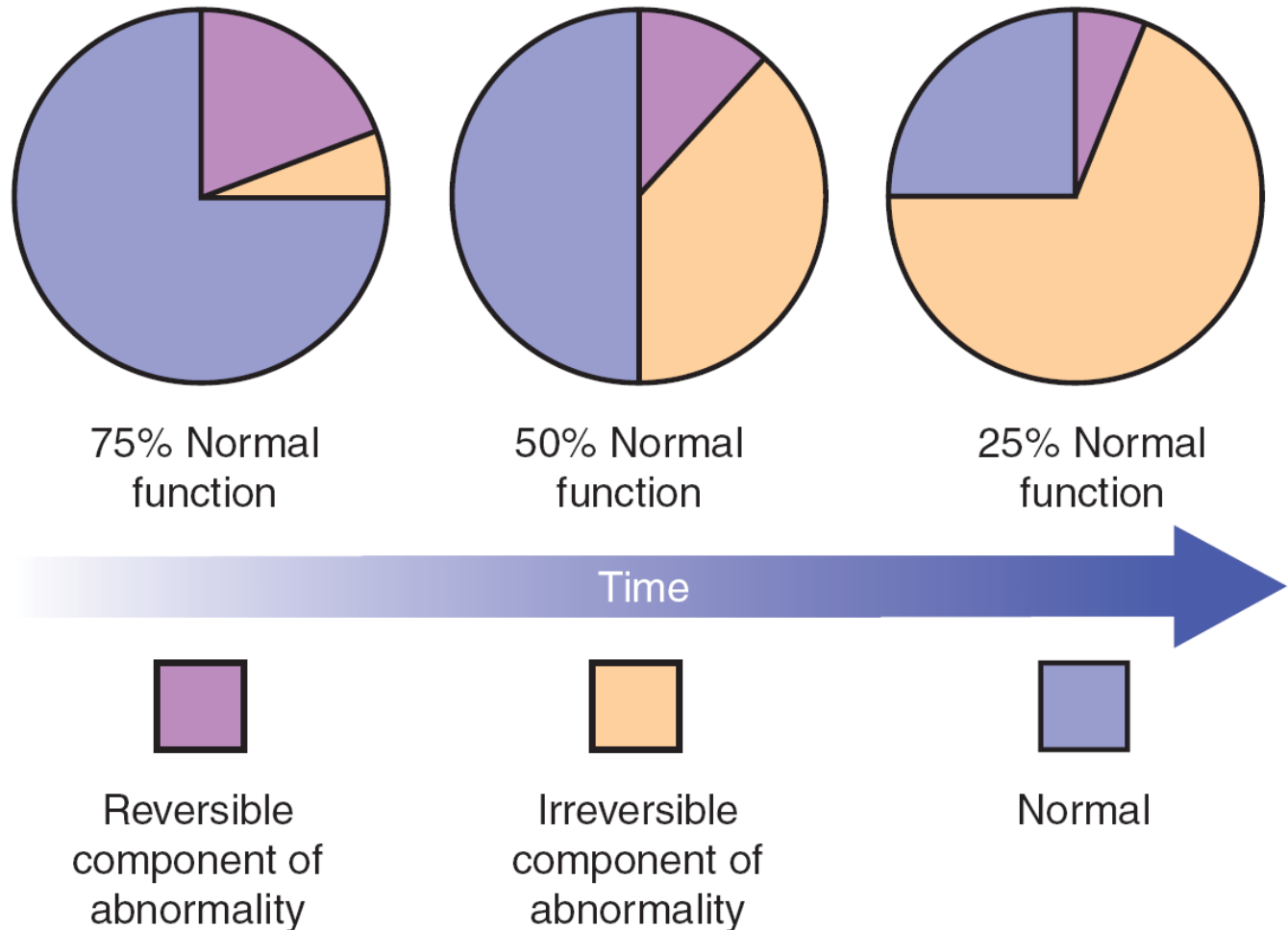
Healthy

Damaged



**Examination of tissues from patients with diabetes reveals capillary damage, neovascularization, and occlusion in the vasa nervorum.**

# Reversible and irreversible components of DPN



# Neuropathy

- **Motor neuropathy**

Weakness and wasting of  
intrinsic foot muscles



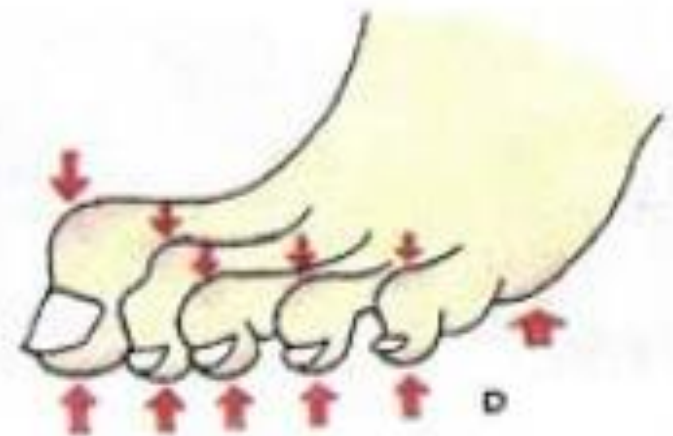
Foot deformities



Abnormal gait

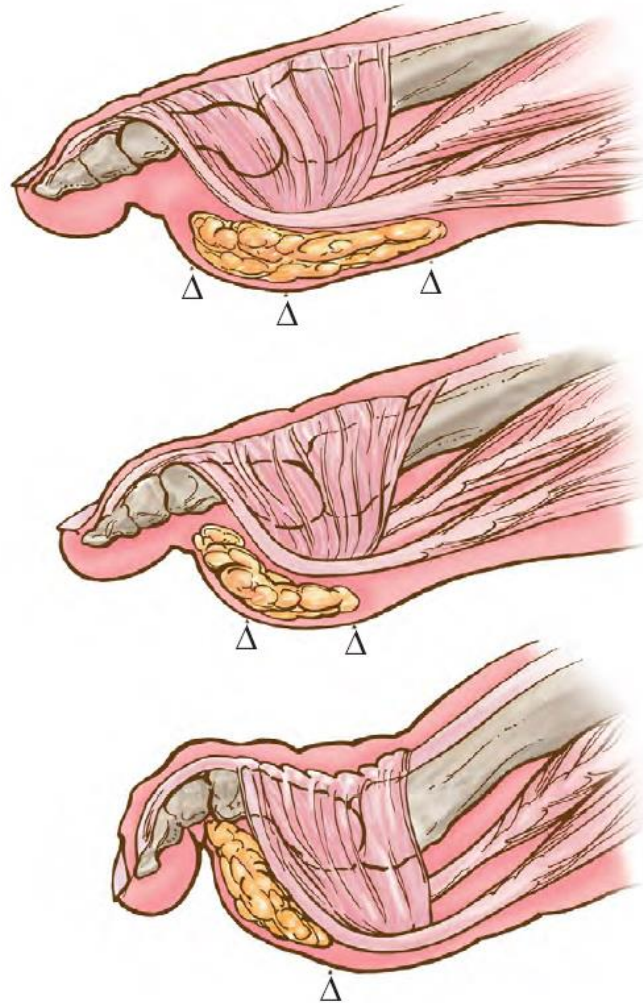


Ulceration





# Development of claw toe deformity



# Neuropathy

- **Sensory Neuropathy**

Loss of pain sensation

↓  
Unnoticed trauma (thermal, chemical, mechanical)

↓  
Progression of lesion unchecked

↓  
Callous formation

↓  
Tissue necrosis & damage beneath callus

↓  
Development of cavities filled with serous fluid

↓  
Erupt into surface

↓  
Results in ulcer formation



Callus formation



Subcutaneous hemorrhage



Breakdown of skin



Deep foot infection  
with osteomyelitis



# Neuropathy

- **Autonomic neuropathy**

Decreased sweating



Dry & brittle skin



Fissures / Cracks



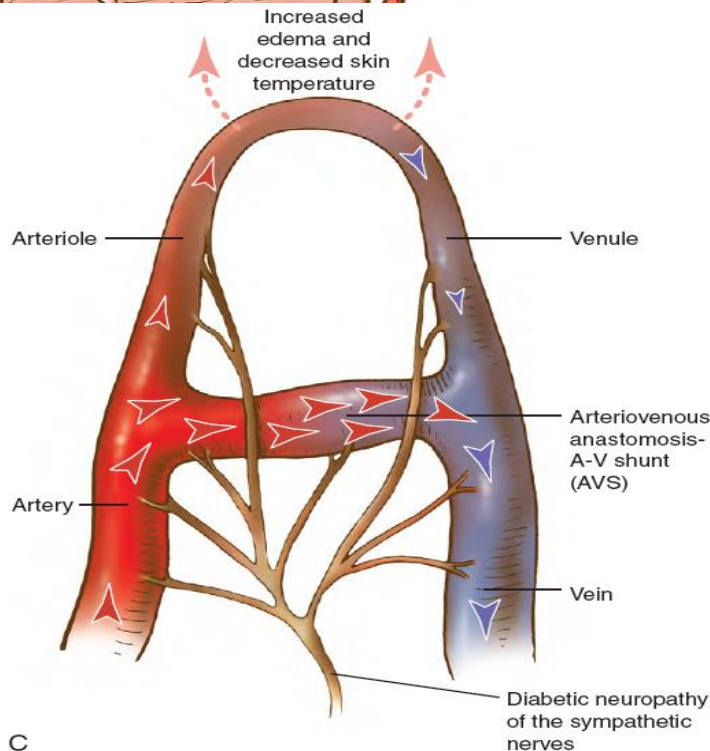
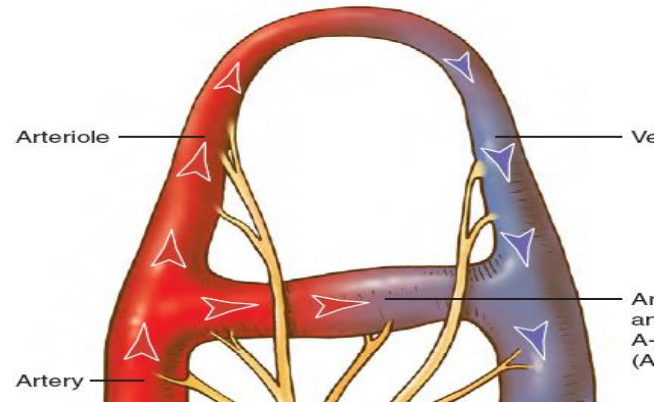
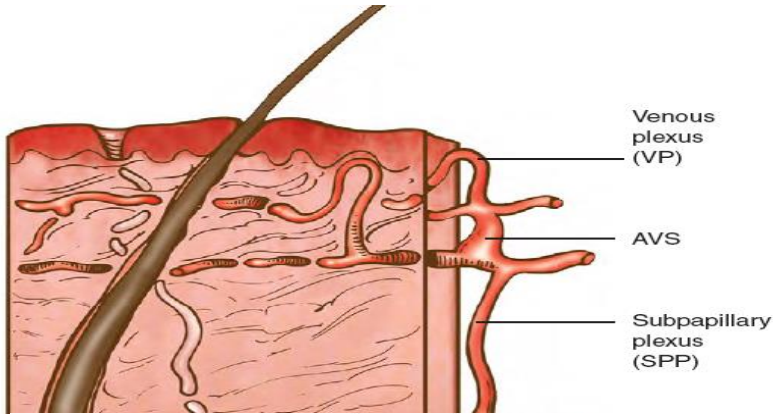
Secondary infection



Ulceration



# AV shunts. Plantar AV shunts in normal and neuropathic diabetic individuals



C

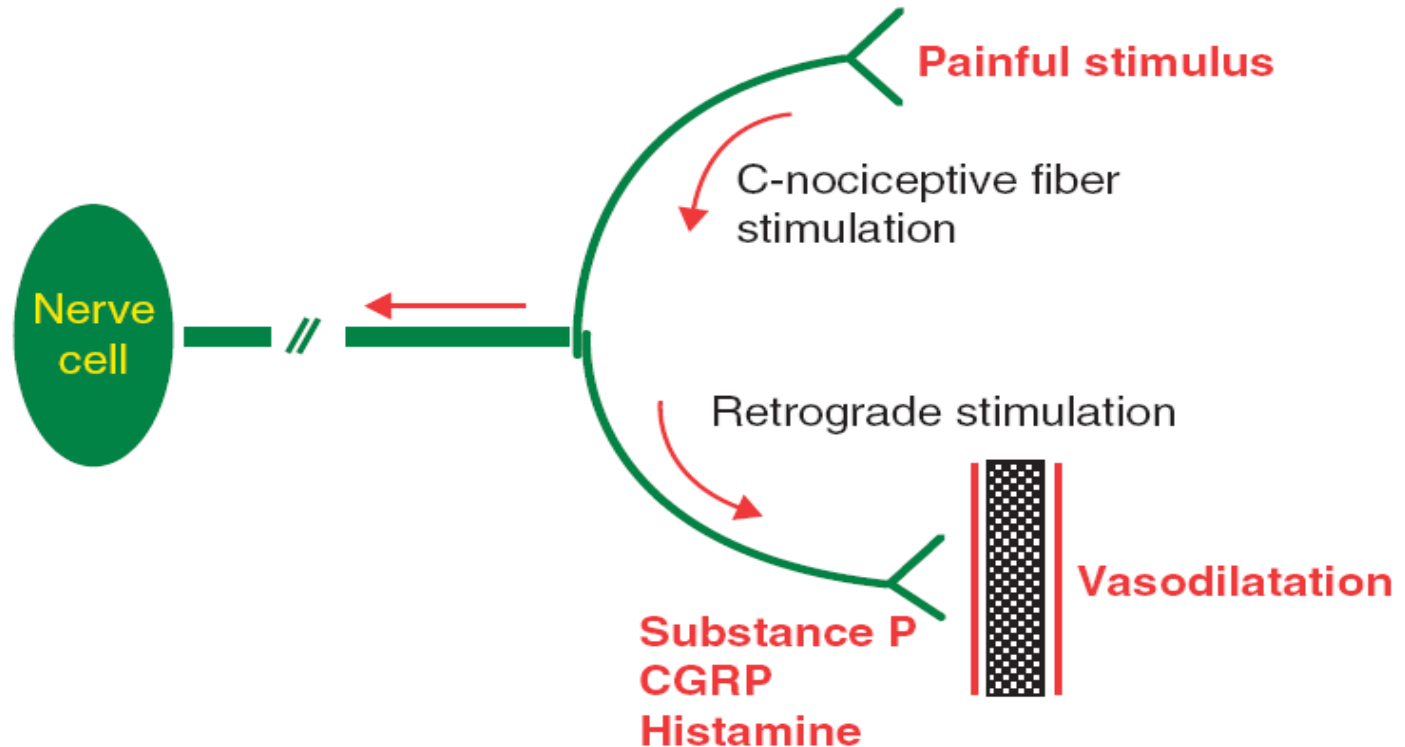
# Autonomic neuropathy



Look for fissure and deformity



# The nerve--axon reflex



**The stimulation of the C-nociceptive fibers causes retrograde stimulation of the adjacent fibers, which release active vasodilators. The final result is hyperemia during injury or inflammation.**



# Nail deformities



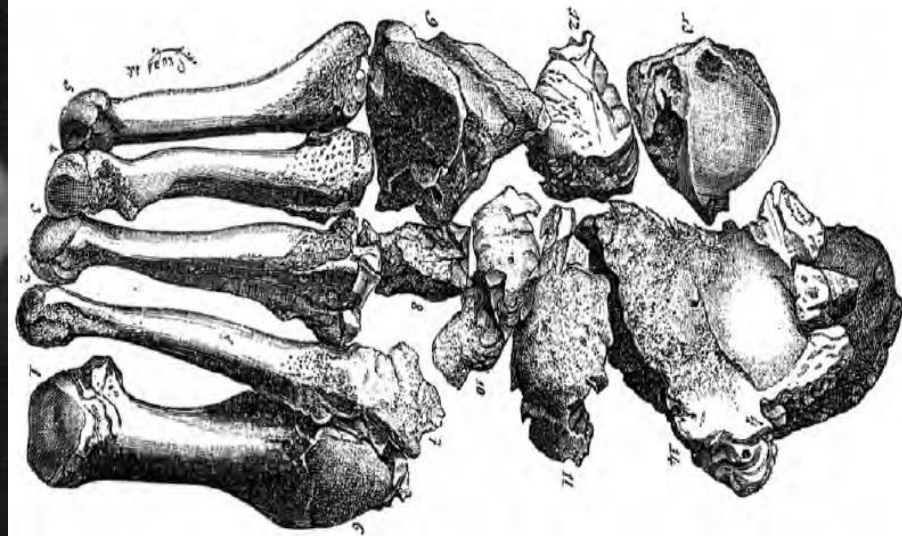
A



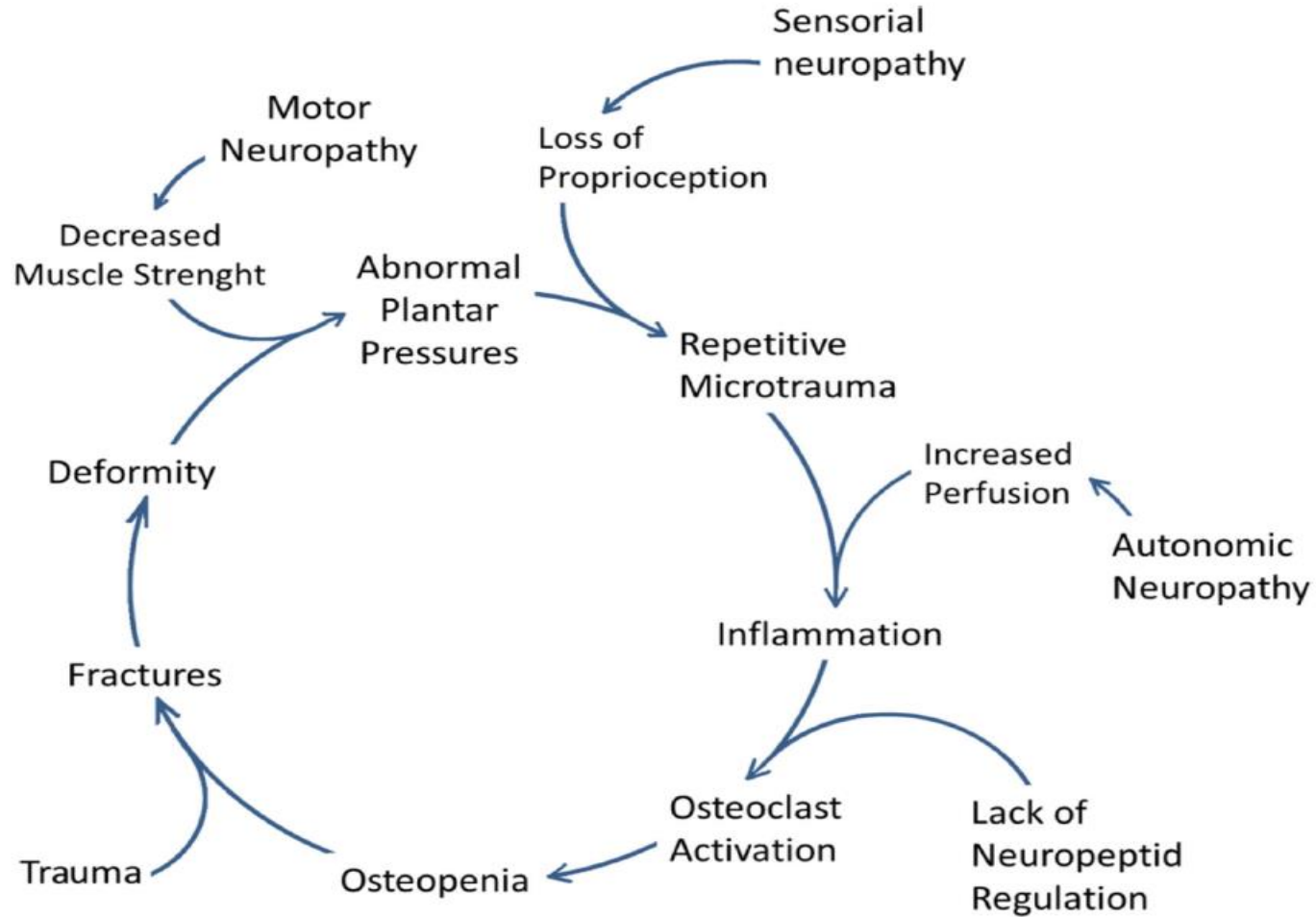
B



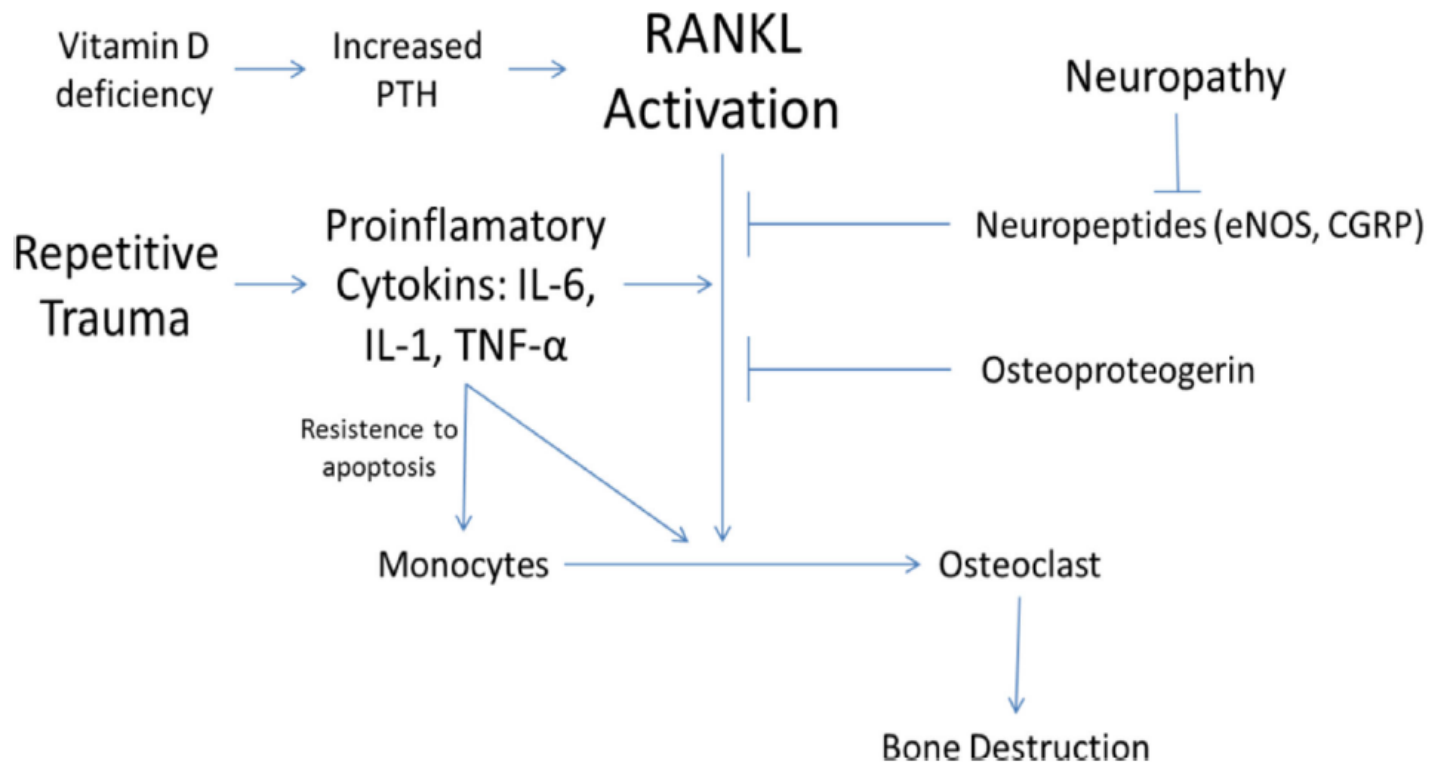
# Charcot Arthropathy



# Cycle of pathophysiology of Charcot osteoarthropathy.



# RANKL pathway in the pathophysiology of Charcot arthropathy.





# Joint stiffness in T2DM patients

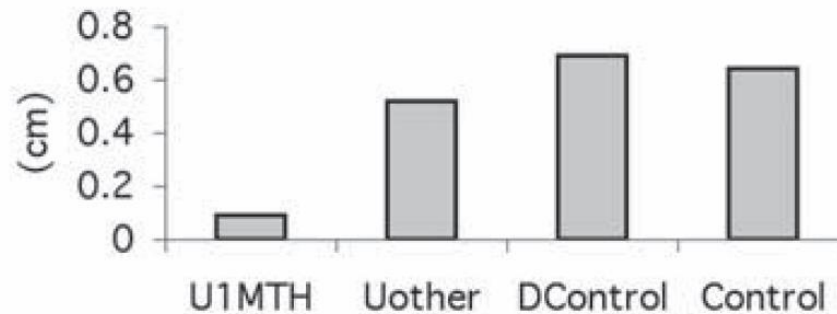
---

Clinical profiles	Right Foot Lesions (% of Patients)	Left Foot Lesions (% of Patients)
<b>Limitation of ROM</b>		
Ankle dorsiflexion	29.6	35.1
Ankle plantar flexion	82.6	84.2
First MTP extension	68.7	79.1

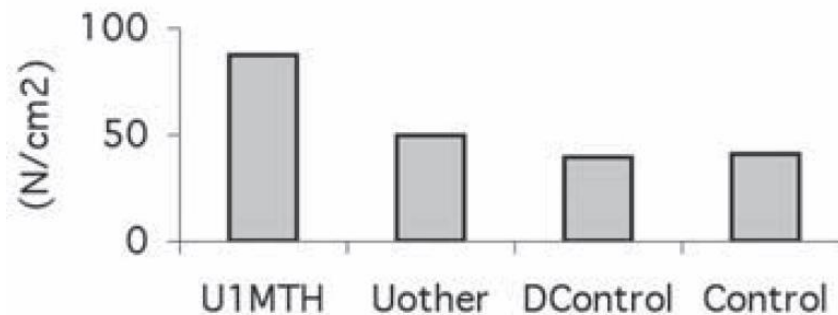
---

# Decrease range increase motion plantar pressure

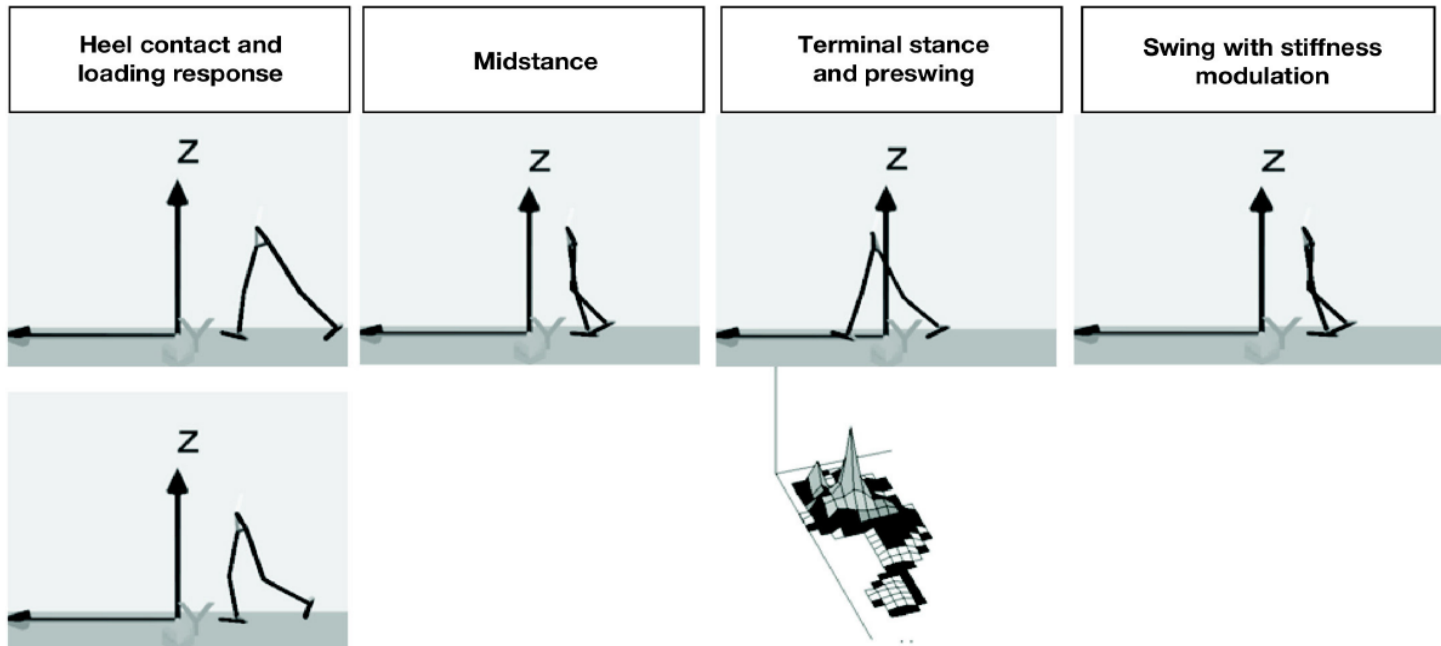
First ray range of motion



Peak pressure

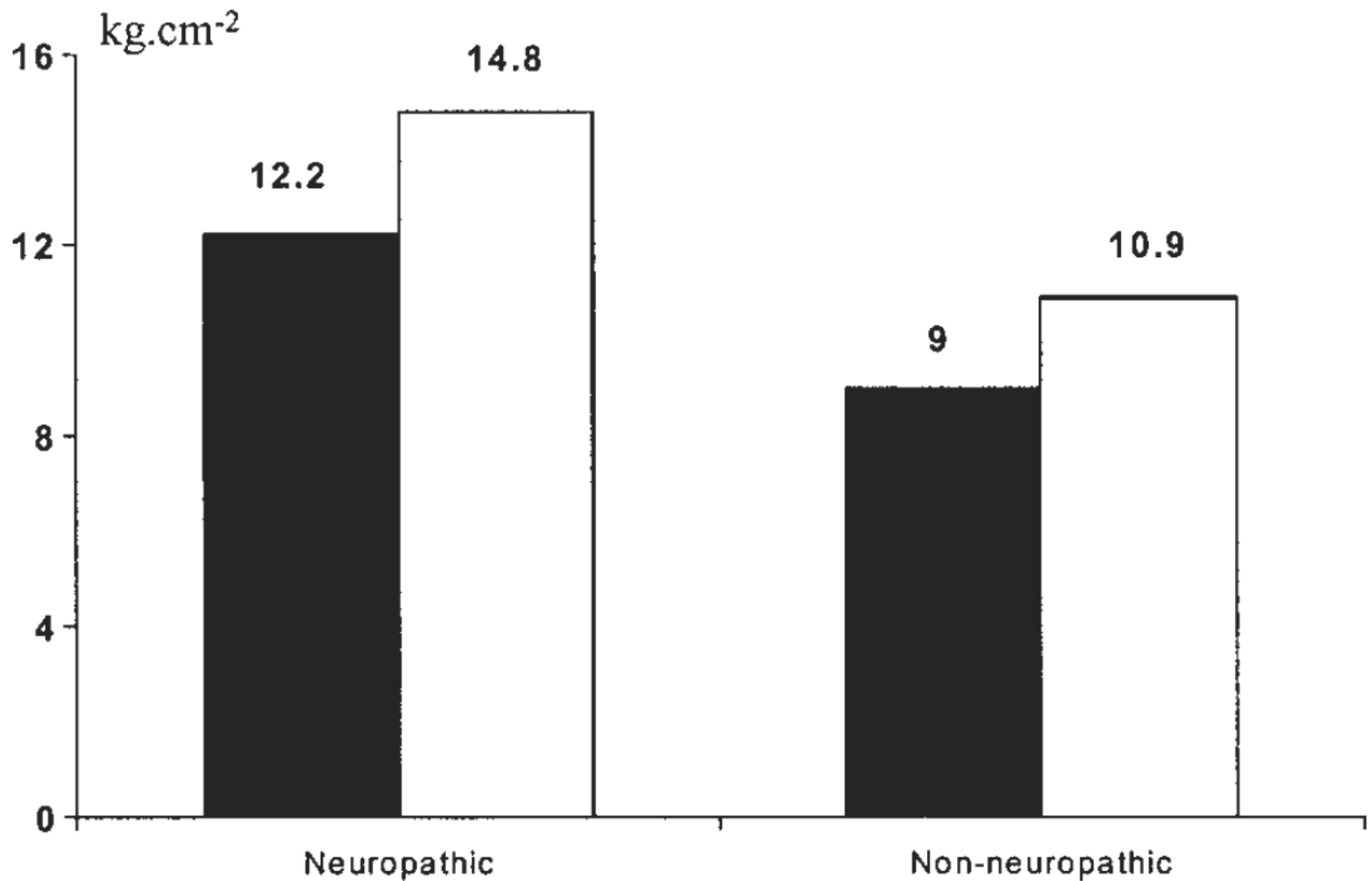


# Gait characteristic changes in persons with diabetes.



<ul style="list-style-type: none"> <li>• Lack of sensory afferent input leads to activation delays at the ankle and knee.<sup>22</sup> Muscle weakness and atrophy combined with fat pad atrophy and increased stiffness affect shock absorption.<sup>11,13,23,37-40</sup></li> <li>• Increased skin hardness and decreased thickness combined with fat pad changes affect the braking force.<sup>13,24,25</sup></li> <li>• These changes including limited joint mobility affect the 1<sup>st</sup> rocker in preserving forward momentum.<sup>28-32</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Lack of sensory afferent input with muscle weakness and limited joint mobility affect single limb support and gait instability.<sup>4,21</sup></li> <li>• Limited joint mobility affects the 2<sup>nd</sup> rocker in preserving forward momentum.</li> </ul>	<ul style="list-style-type: none"> <li>• Limited joint mobility affects ability to generate ankle plantar flexor torque and muscle weakness affect vertical ground reactive force.<sup>46</sup></li> <li>• Wider based of gait combined with skin, and fat changes affect medial-lateral shear and pushing force.</li> <li>• Limited joint mobility, activation delays of tibialis anterior, and gait instability affect 3<sup>rd</sup> rocker in preserving forward momentum and passive toe off.</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of sensory afferent input with muscle weakness and limited joint mobility affect single limb support.</li> <li>• Gait instability<sup>4,21</sup> coupled with above affect modulation of lower extremity stiffness and cognitive pre-preparation of the limb.</li> <li>• Gait perturbation objects in home environment where 52% of steps are taken can affect this.</li> </ul>
--	--	---	---

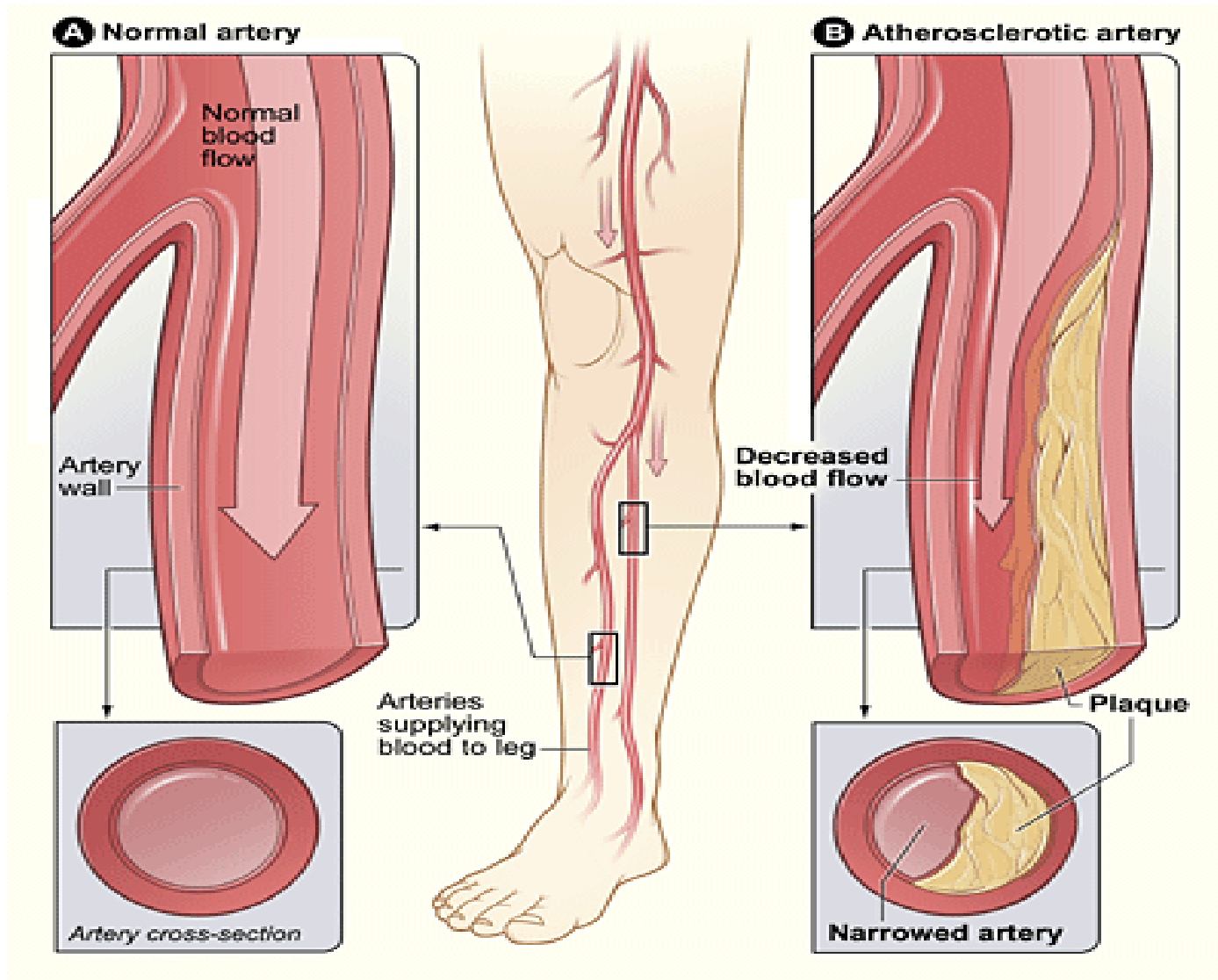
# Changes in the peak foot pressures



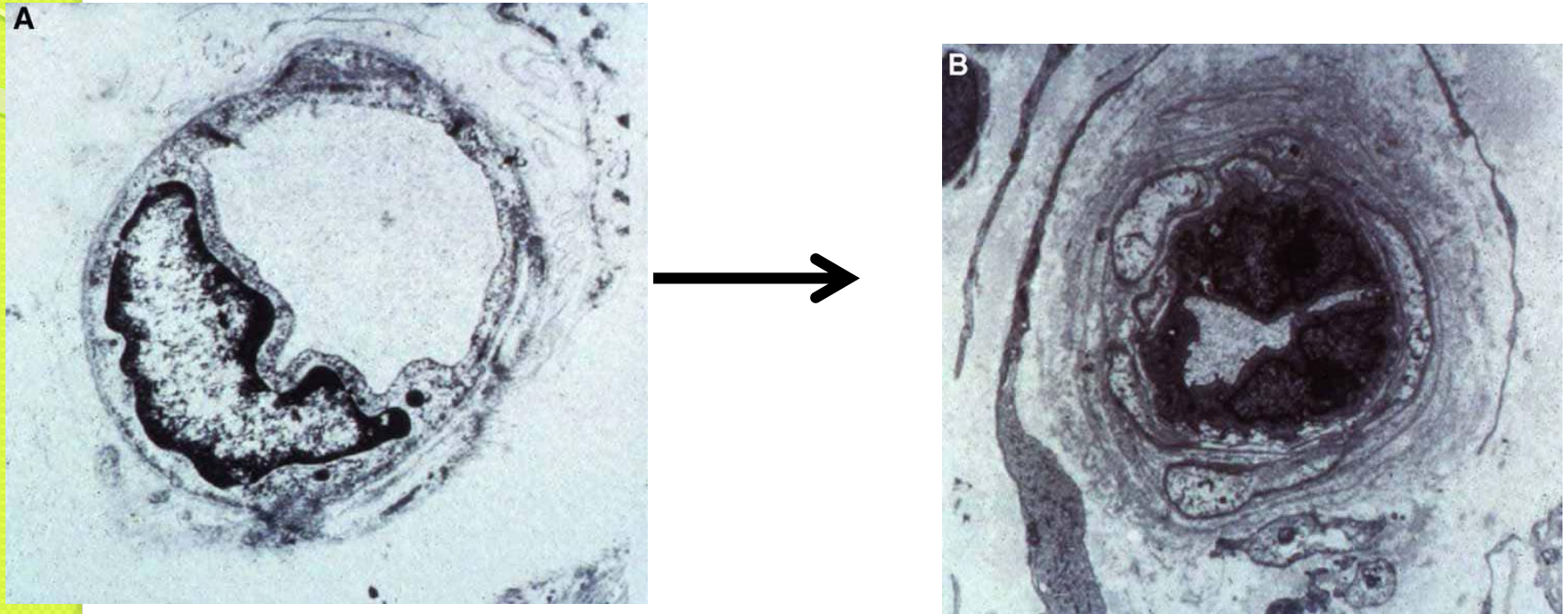
Veves A, Et al. *Diabetologia* 1992;35:660–663.



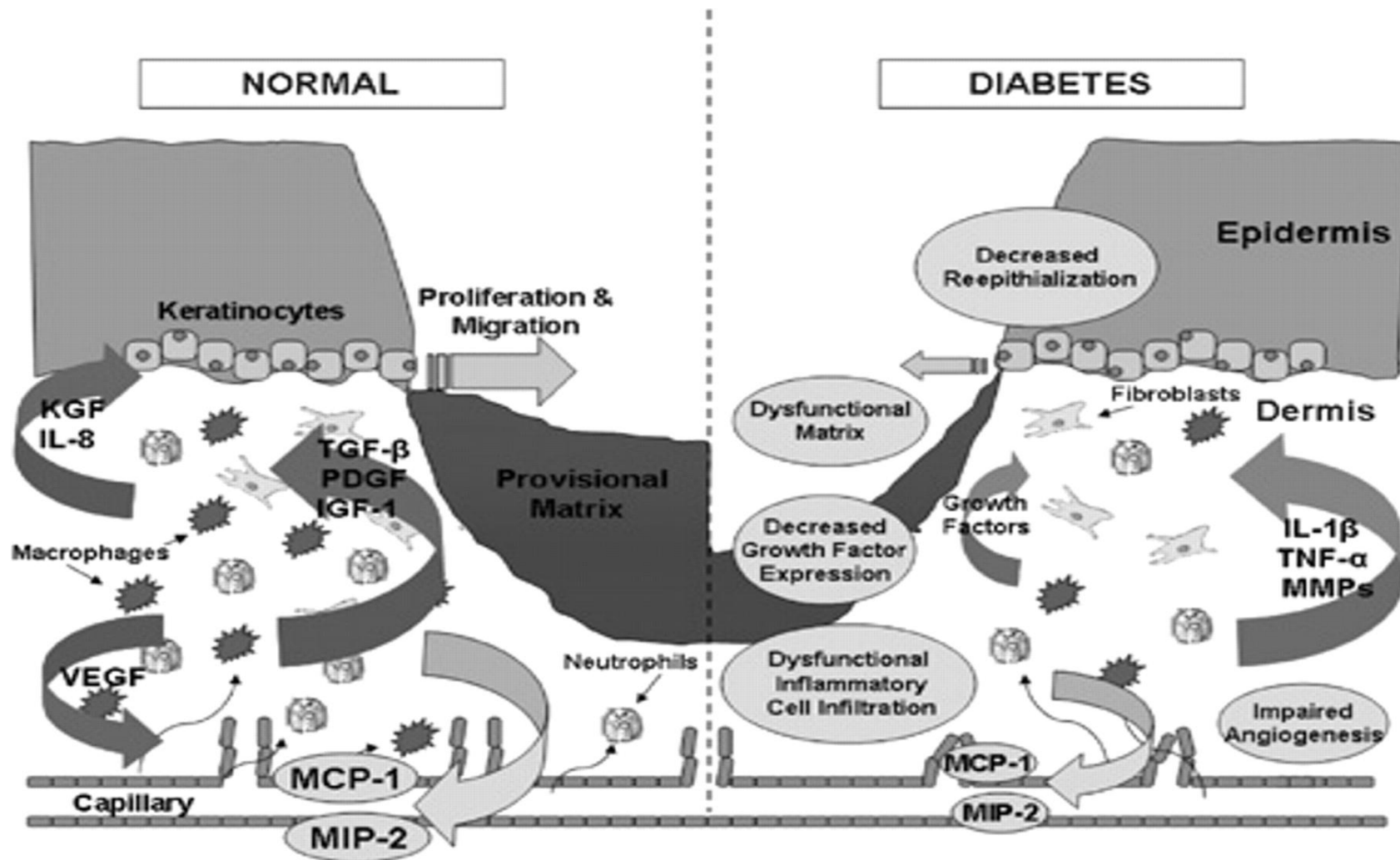
# Artherosclerosis in diabetes



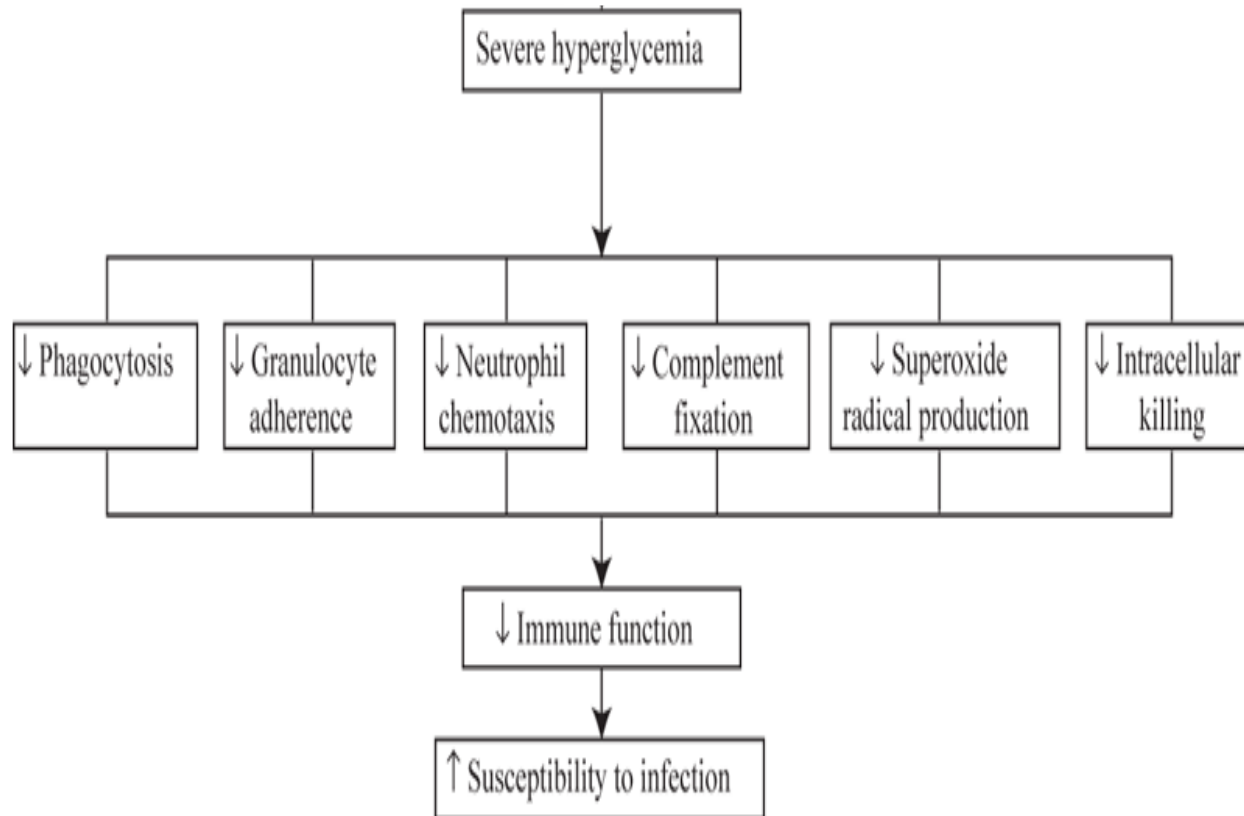
# *Microvascular Changes in the Diabetic Foot*



# Impaired wound healing in diabetes



# Diabetes and infection





# Biofilm



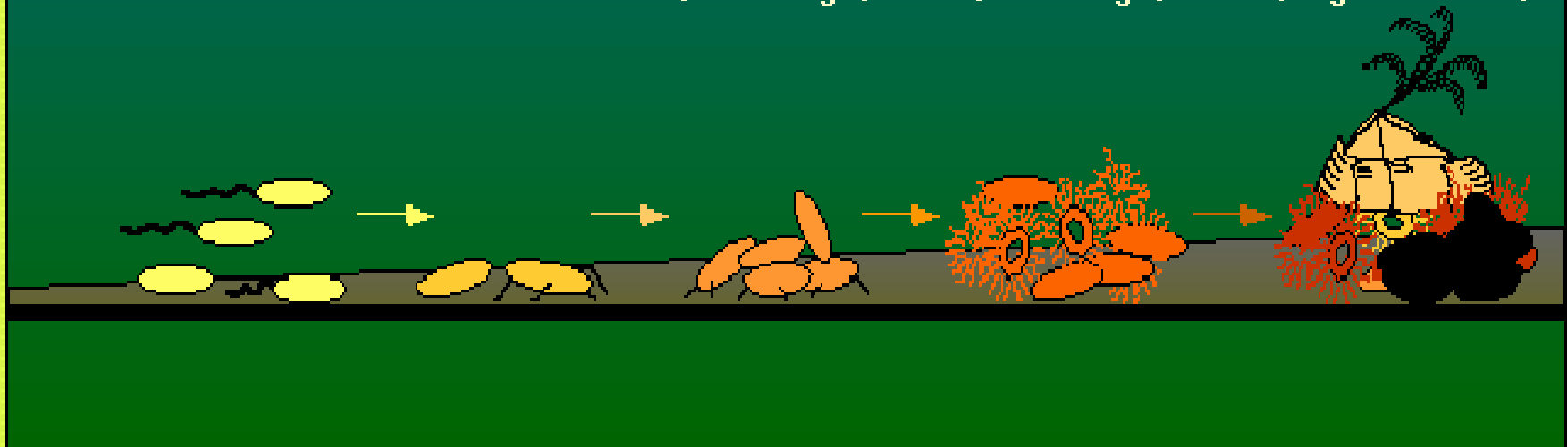
REVERSIBLE  
ADSORPTION  
OF BACTERIA  
(sec.)

IRREVERSIBLE  
ATTACHMENT  
OF BACTERIA  
(sec.-min.)

GROWTH &  
DIVISION  
OF  
BACTERIA  
(hrs.-days)

EXOPOLYMER  
PRODUCTION  
& BIOFILM  
FORMATION  
(hrs.-days)

ATTACHMENT  
OF OTHER  
ORGANISMS TO  
BIOFILM  
(days-months)



# OTHER RISKS FOR ULCER/AMPUTATION

## **Failure to adequately care for the feet:**

- Inadequate patient education
- Inadequate patient motivation
  - Depression, anxiety, anger more common in diabetes
- Physical disability
  - Cannot see feet 2° to retinopathy
  - Cannot reach feet 2° to obesity, age (?50% of patients)
- Limited access to podiatry services

# Type of Footwear Used by Patients

Type of Footwear	Percentage
Slippers	67.2
Low heel shoes	8.8
High heel shoes	1.4
Sports shoes	3.5
Others	19.1

# Self Foot Care Procedures

	First Visit		Second Visit	
	Recognition	Strictly Followed	Recognition	Strictly Follow
1. Inspected feet daily	96.5	77.9	97.6	79.6
2. Washed feet daily with warm water and mild soap	98.2	96.7	98.8	97.8
3. Applied moisturizing cream after washing	71.8	39.5	73.4	40.7
4. Wore socks and made sure they were big enough	88.6	50.5	88.3	52.4
5. Inspected footwear to see whether any small object was caught in the shoe	96.1	84.2	94.8	86.3
6. Did not submerge feet into hot water	41.3	35.2	62.9	42.7
7. If there was swelling, redness, or pus, consulted doctor immediately	88.8	62.0	88.9	63.9
8. While cutting toenails, never poked down the edges or tried to cure the ingrown toenail themselves	68.7	49.7	69.3	51.6
9. Exercised feet regularly	96.1	70.1	94.6	72.9
10. Did not or stopped smoking	46.8	90.0	48.0	91.98

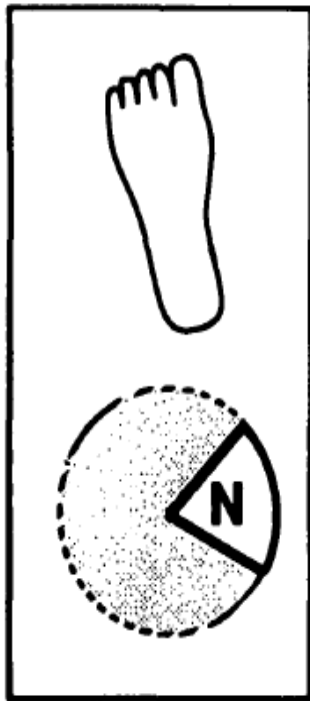
Kittipan Rerkasem. [Int J Low Extrem Wounds](#). 2011 Jun;10(2):86-90



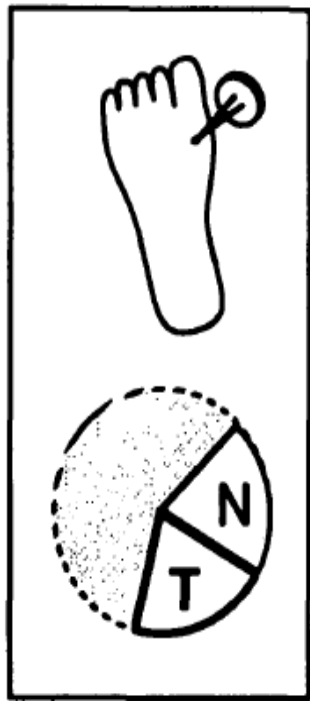
# Sociocultural Practices and foot ulcers



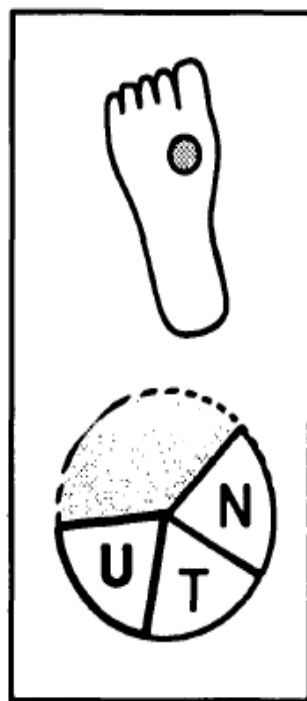
Kittipan Rerkasem. [Int J Low Extrem Wounds](#). 2011 Jun;10(2):86-90



**NEUROPATHY**



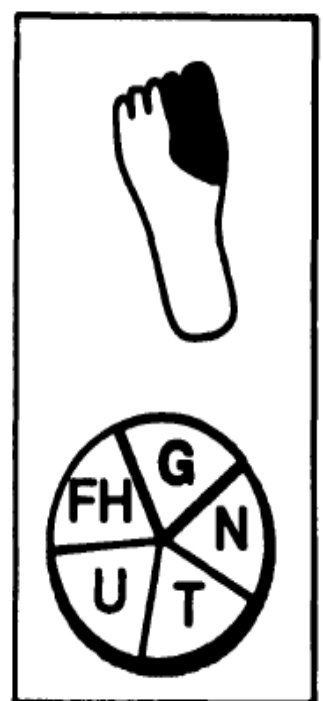
**MINOR TRAUMA**



**ULCERATION**



**FAULTY HEALING**



**GANGRENE**

**BASELINE  
PATHOLOGY**

**+**

**ENVIRON-  
MENTAL  
EVENT**

**+**

**SKIN  
LESION**

**+**

**INTERCURRENT  
PATHO-  
PHYSIOLOGY**

**+**

**INTERCURRENT  
PATHO-  
PHYSIOLOGY**

**ACCUMULATION of COMPONENT  
CAUSES TO FORM A SUFFICIENT CAUSE**

**COMPLETED  
CAUSAL CHAIN  
TO AMPUTATION**