

Multidisciplinary Approach to Limb Salvage in diabetic Patients

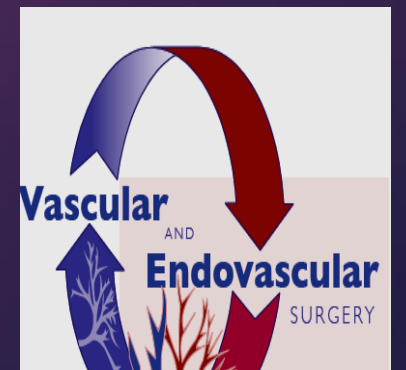
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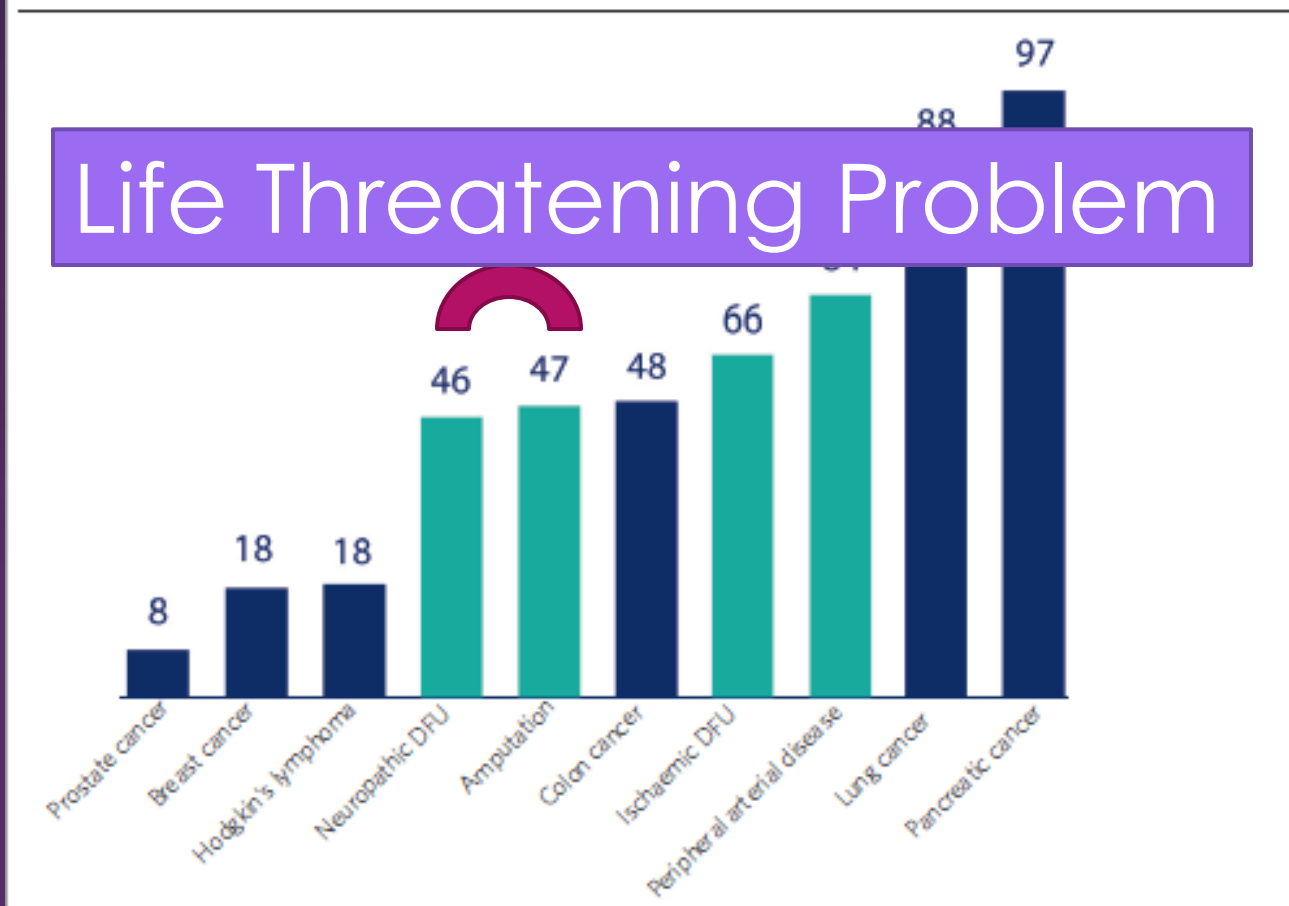
Disclosure

NONE

Objectives

- ▶ Epidemiology
- ▶ Factors contributing to Diabetic Foot Ulcer
 - ▶ Ischemia
 - ▶ Infection
 - ▶ Neuropathy
 - ▶ Bone Deformity
- ▶ Multidisciplinary approach

FIGURE 1: Relative five-year mortality (%) (adapted from¹⁹)



Armstrong et al, int wound J 2007

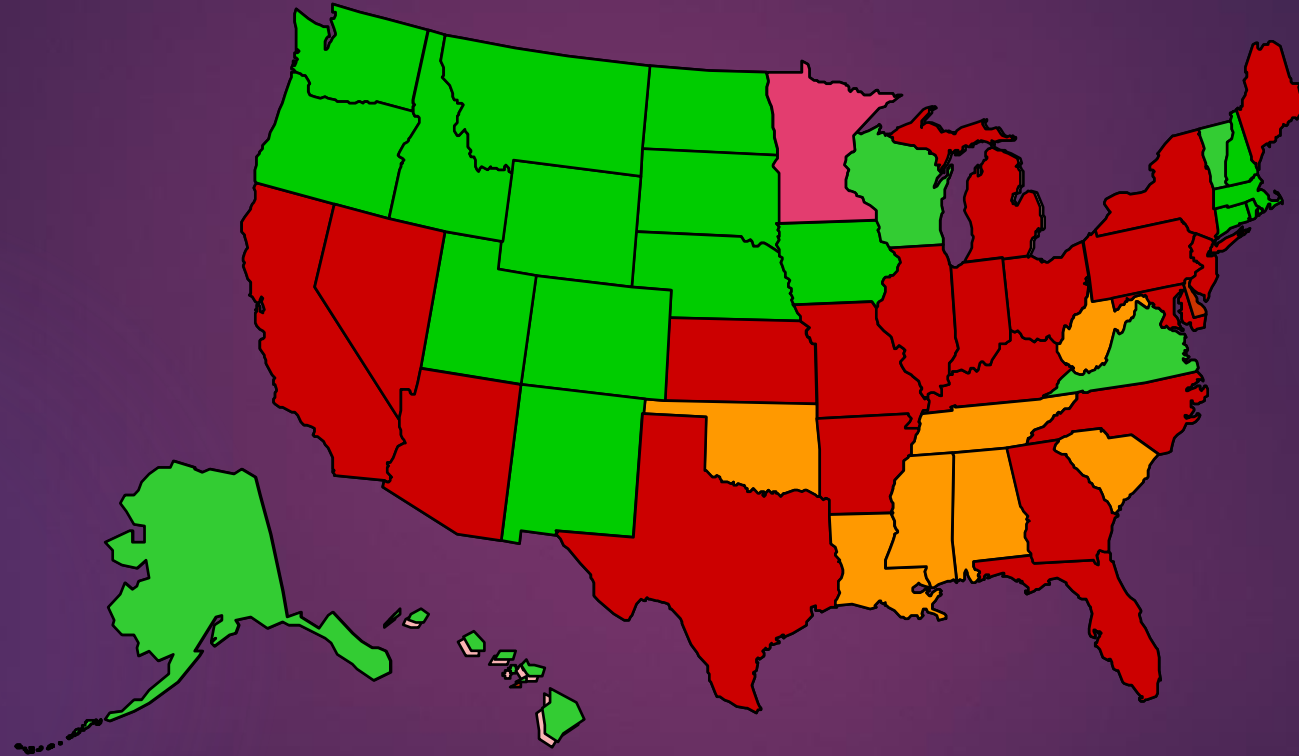
The epidemic in the US...

- ▶ 26% increase in incidence of diabetes (5 years)
- ▶ 41% increase in expenditures from 2007 (5 years)
- ▶ >20% US health care expenditures
- ▶ Per capita cost 2.3 x higher for diabetes
- ▶ 8% of population – 20% expenditures

**Economic costs of diabetes in the US in 2012,
Diabetes Care 2013**

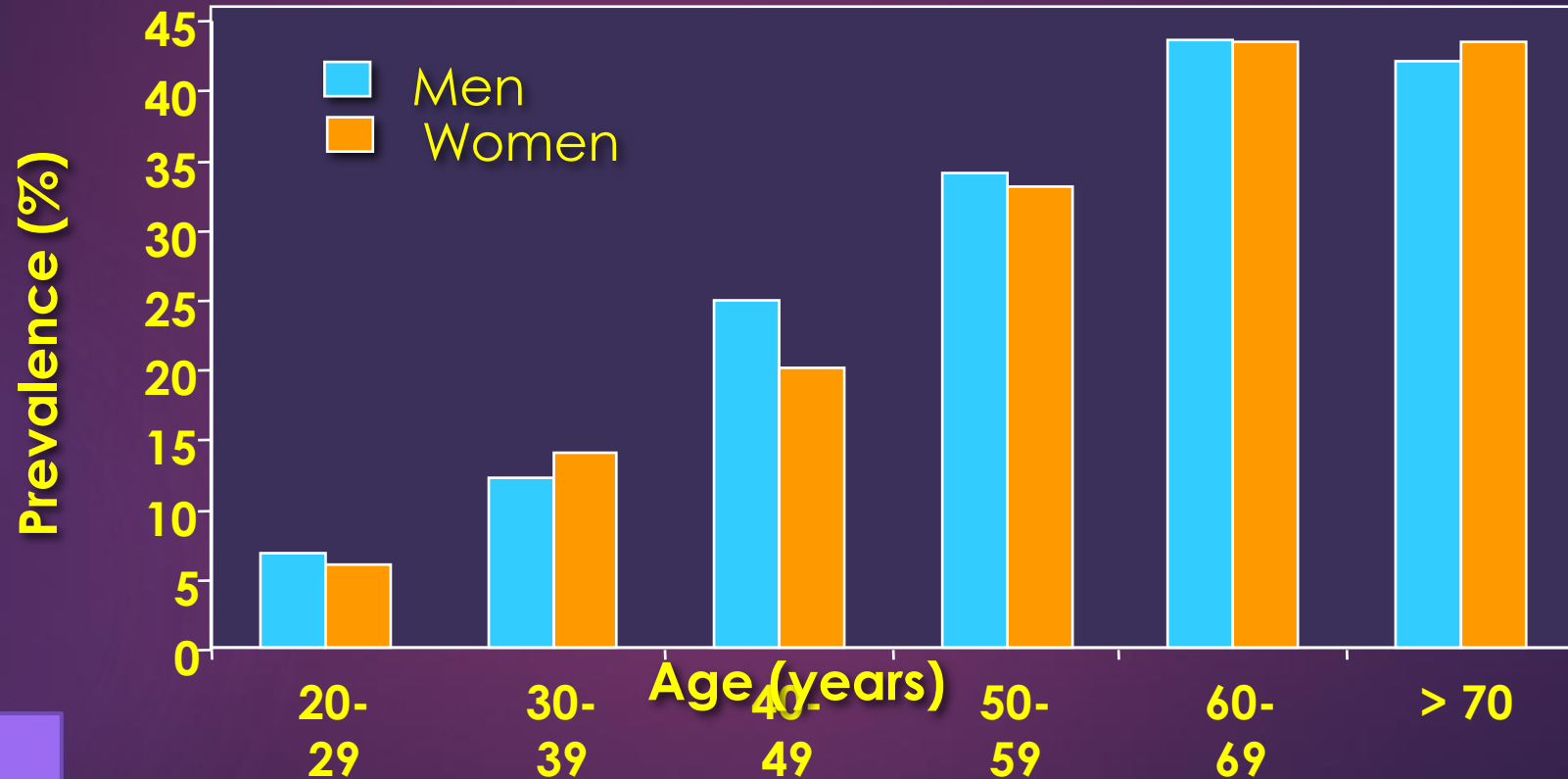
Diabetes in the US: 2008

CDC BRFSS: Self-Reported Diabetes: 8.2% Nationwide



4 – 6%  6 – 8%  8 – 10%  10 – 12% 

Prevalence of the Metabolic Syndrome Among US Adults 1988-1994



Hidden
Problem

Ford E et al. JAMA. 2002(287):356.

DFU: Facts

No ulcer is benign

Healing is not the rule, but remission is.

Good Doppler is not good blood supply in DFU

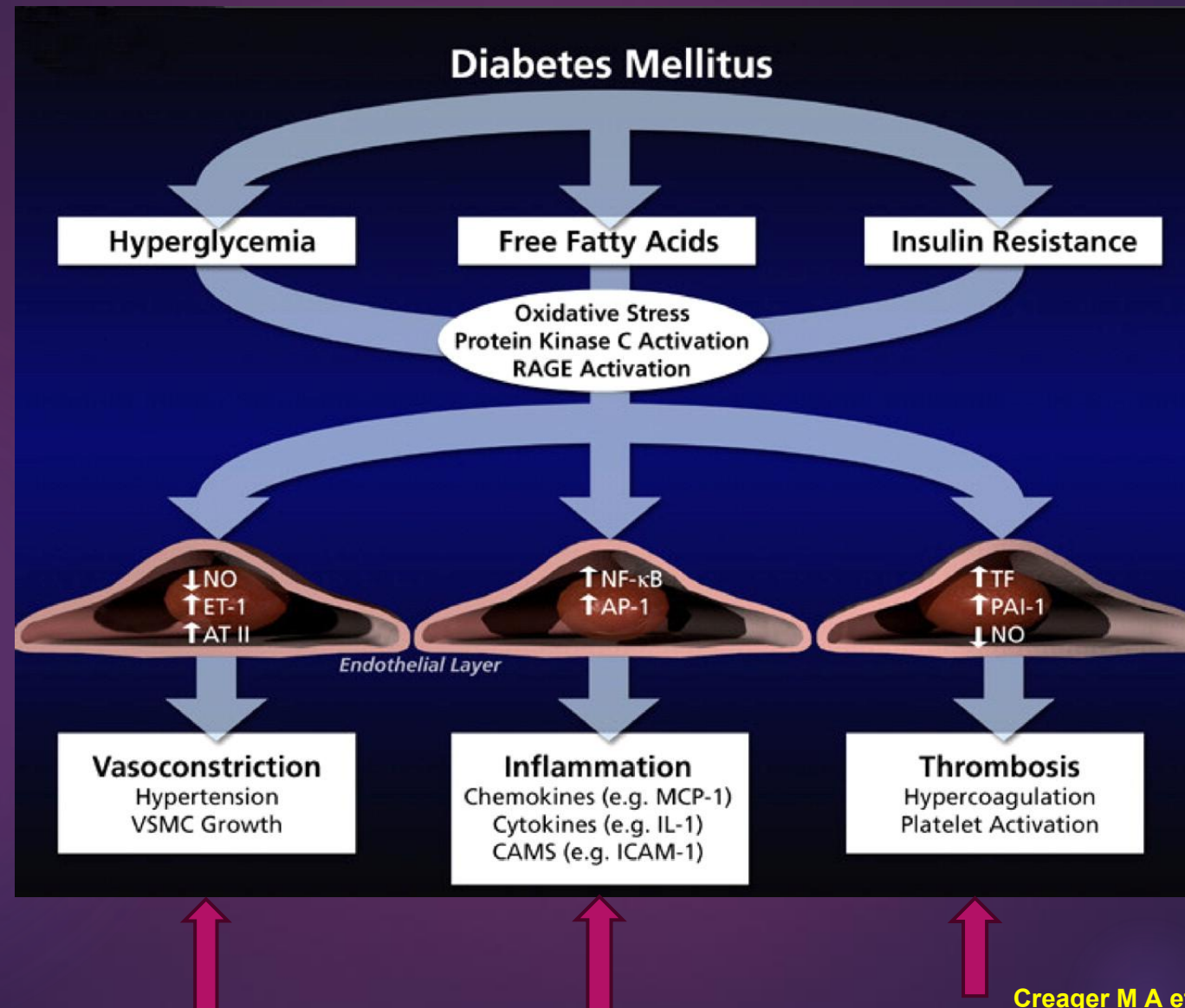
Good pedal pulses does not mean good perfusion

Angiosomes play a role

Musculoskeletal organ not normal

Infection assumed until full healing

Figure 2. The metabolic abnormalities that characterize diabetes, particularly hyperglycemia, free fatty acids, and insulin resistance, provoke molecular mechanisms that alter the function and structure of blood vessels.



Diabetic foot ulceration and re-ulceration

Ulcer incidence is 2-7% per year

9 -20% of ulcers end in amputation

28-83% re-ulcerate within 12 months

Uciolli, Diabetes Care 1995

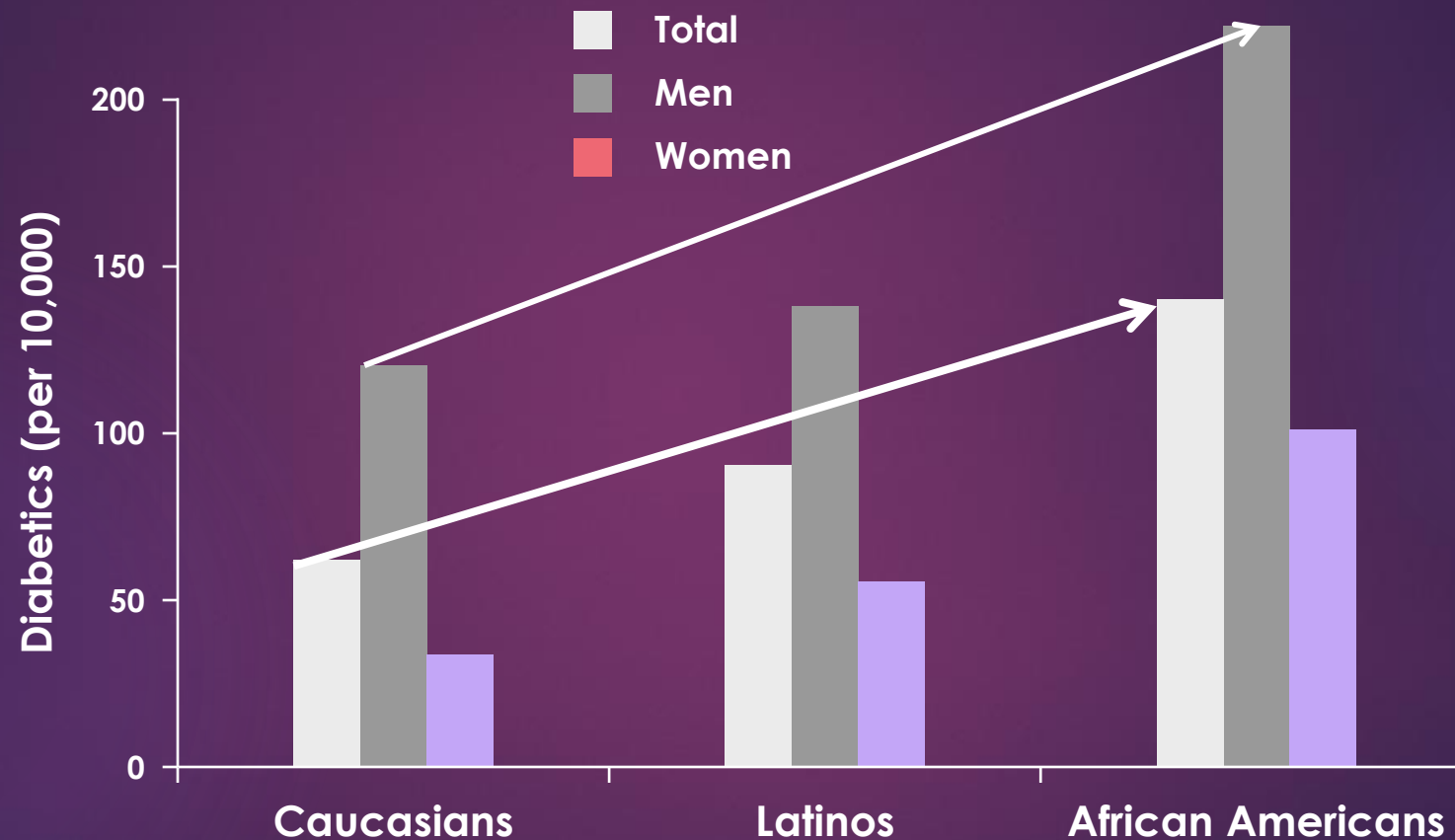
Walker, Arch Phys Med Rehab 1986

Gap between Evidence and Practice in Diabetes Care

30% to 40% of
patients not
treated according
to evidence

20% to 25% of
care is not
needed or
dangerous

Amputation Incidence in African Americans, Latinos, Caucasians



Lavery LA, et al. *Diabetes Care*. 1995;18(11):1460-1462. Van Houtum WH, et al. *Diabetes Care*. 1998;9(117):643-648.

Grading-Diabetic Ulcers



Most commonly used scale- Wagner Grade



University of Texas



Society for Vascular Surgery Lower Extremity Threatened Limb Classification System (Wifl)

Wagner Grading

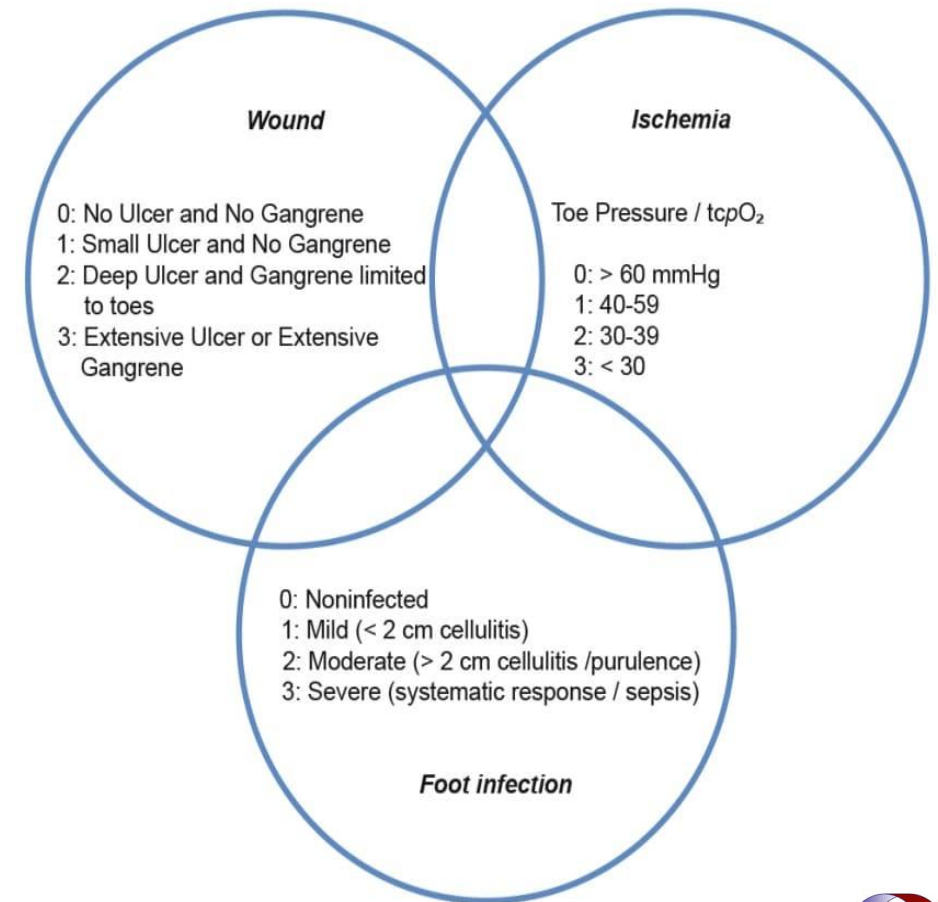
- 0** - Intact Skin
- 1** - Superficial ulcer of skin or subcutaneous tissue
- 2** - Ulcers extend into tendon, bone, or capsule
- 3** - Deep ulcer with osteomyelitis or abscess
- 4** - Gangrene of toes or forefoot
- 5** - Midfoot or hindfoot gangrene



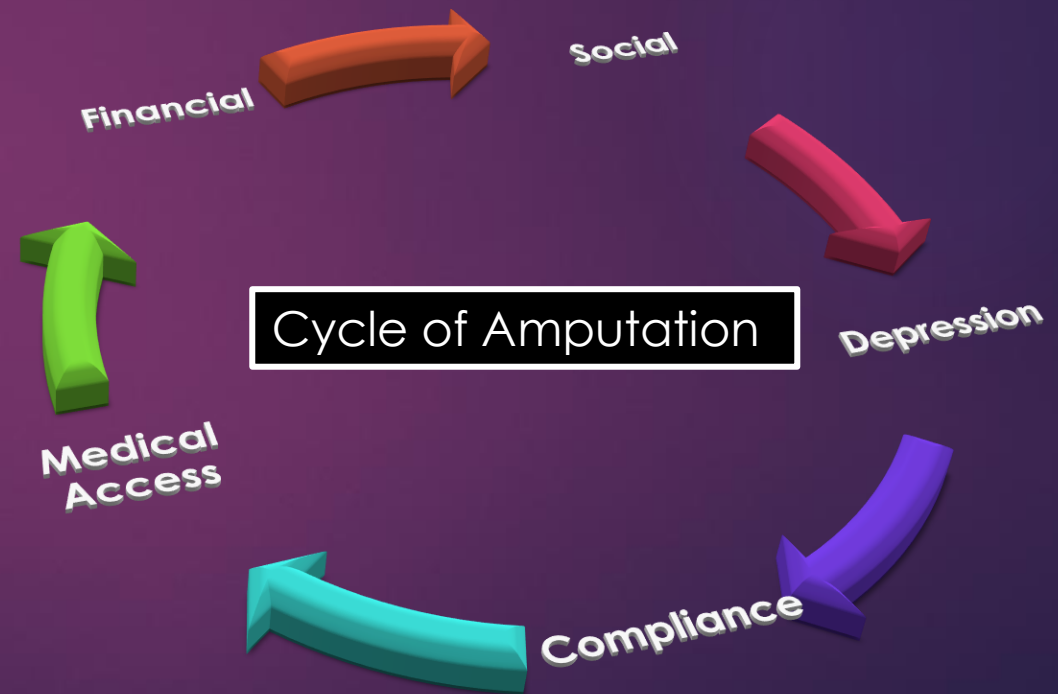
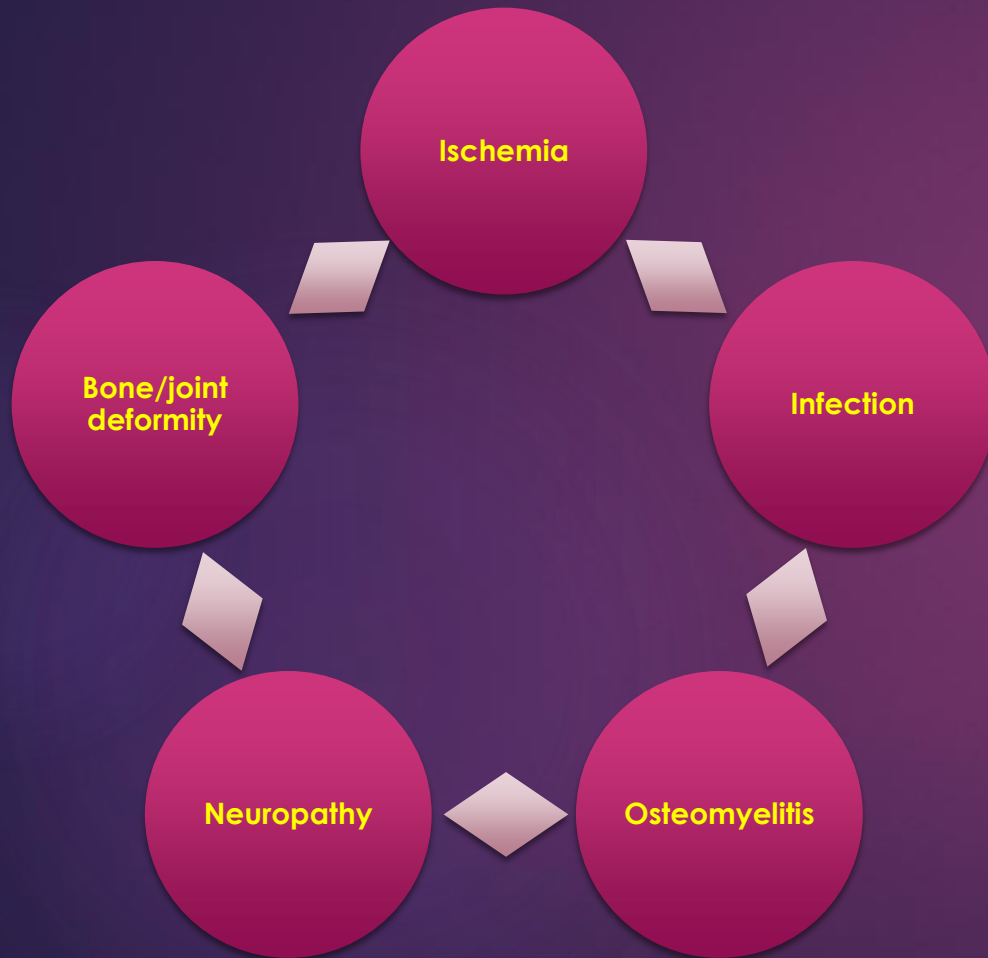
Wifl

- Wound grades 0-3 based on size depth, severity
- Ischemia: ABI, ankle systolic pressure, TcPO₂
- Infection: from local/superficial to deep/systemic

Mills, et al., 2014



Diabetic Foot Complex



Risk Factors: Foot Ulcers

History of Ulcer strongest predictor

Systemic Risk Factors	Odds Ratio
Male gender	2.6 – 5.7
Age >65	2.0
Duration of diabetes	1.06 – 4.5
Poor glycemic control	3.0 – 3.2
Retinopathy	1.9 – 3.0
Nephropathy	2.2 – 4.6
Retinopathy	1.4 – 3.9

Lavery L, et al. *J Fam Pract.* 2000;49(suppl 11):S9-S16.

Z. Merza, S. Tesfaye/The Foot 13 (2003) 125–129

► Edelman, JCOM, 1999

Clinical Characteristics	Annual Risk of Ulcer
History of ulcer or amputation	33%
Insensate to 5.07 monofilament, bony deformity, no history of ulcer or amputation	19%
Insensate to 5.07 monofilament, no bony deformity, no history of ulcer or amputation	11%
Normal examination, no history of ulcer or amputation	0.6%

Foot Deformity

Foot deformity in DM

DIABETES RESEARCH AND CLINICAL PRACTICE 82 (2008) 226–232



available at www.sciencedirect.com



journal homepage: www.elsevier.com/locate/diabres



Foot ulcer risk and location in relation to prospective clinical assessment of foot shape and mobility among persons with diabetes

Matthew S. Cowley^a, Edward J. Boyko^{b,c}, Jane B. Shofer^a, Jessie H. Ahroni^{d,e},
William R. Ledoux^{a,f,g,*}

- ▶ Assessed baseline clinical foot shape for 2939 feet of diabetic subjects who were monitored

Conclusions: Certain foot deformities were predictive of ulceration, although there was no relationship between clinical foot deformity and ulcer location

High Risk for ulcer

Hammer/claw
toes

Bony
prominence

Charcot feet

Low Risk for ulcer

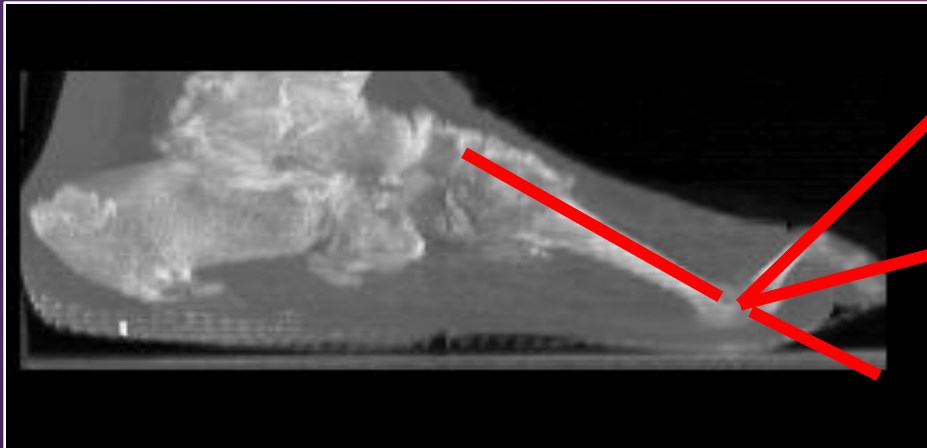
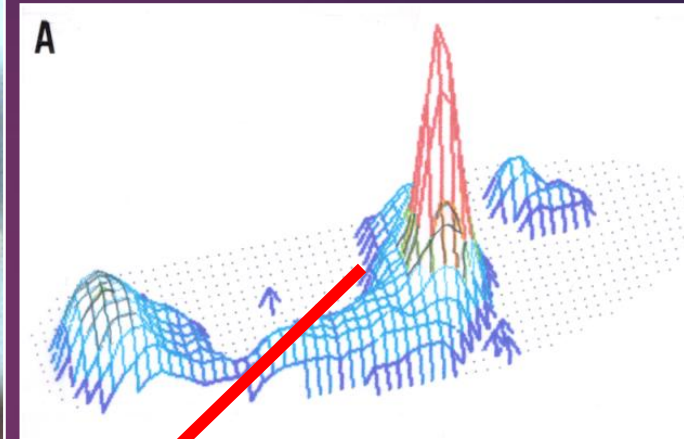
Pes cavus

Pes planus

Risk Factors: Foot Ulcers

Local Risk Factors	Odds Ratio
History of ulcer-amputation	1.6 – 40.5
Sensory neuropathy	7.2 – 32.5
Peripheral Vascular Disease	2.4 – 3.0
Abnormal biomechanics	
• Limited joint mobility	2.1 – 2.3
• Structural deformity	3.3 – 3.5
• Plantar foot pressure	2.0 – 5.9

Mechanics of Foot Ulceration



Diab

Most t
under
where



hest

Lavery L, et al. *Am Fam Physician*.1998a;57:1325-1328. Mueller MJ, et al.
Diabetes Care. 2008;31:1679-1685.

al.

Diabetic Foot Risk Classification

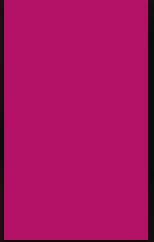
Incidence of Complications

N = 1,666	Ulcer	Amputation	Hospitalization
1. No disease	2.0%	0	0
2. Neuropathy	4.5%	0	1.0%
3. Neuropathy + deformity	3.0%	0.7%	1.8%
4. PAD	13.8%	3.7%	15.9%
5. Ulcer history	31.7%	2.2%	8.2%
6. Amputation history	32.2%	21.0%	50%

Risk of Amputation after DFU

- ▶ 11 times higher if positive probe to bone test.
- ▶ 90 times higher if infection and ischemia.
- ▶ Osteomyelitis location: the heel has highest rate of amputation

Armstrong et al , diabetic foot care, 1998



PVD in Diabetes

CVD in DM

- ▶ Atherosclerotic complications responsible for
 - ▶ 80% of mortality among patients with diabetes
 - ▶ 75% of cases due to coronary artery disease (CAD)
 - ▶ Results in >75% of all hospitalizations for diabetic complications
- ▶ 50% of patients with type 2 diabetes have preexisting CAD.
- ▶ 1/3 of patients presenting with myocardial infarction have undiagnosed diabetes mellitus

PVD in Diabetics

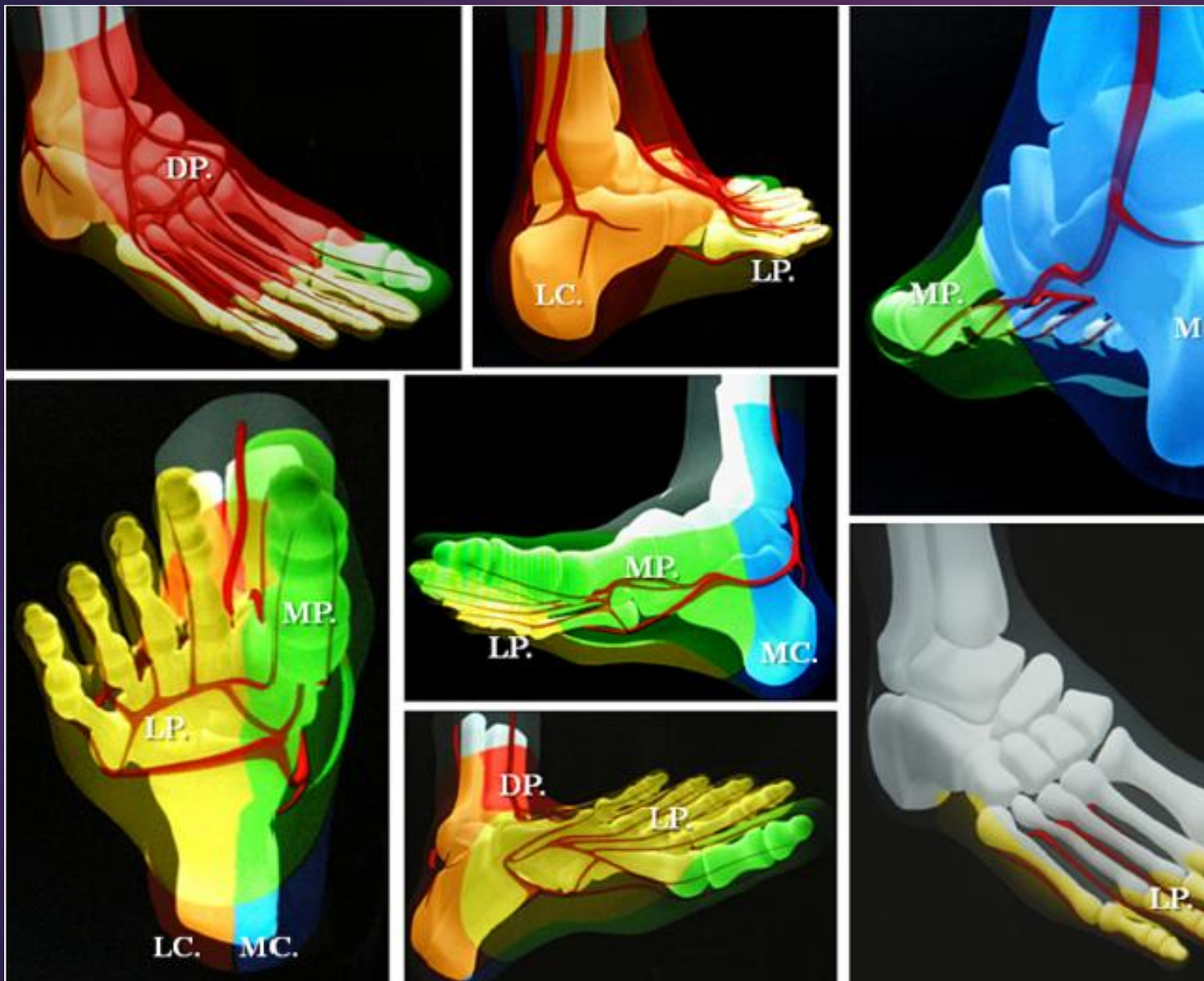
PVD at least 20x in diabetics vs nondiabetics.

Increased risk of CAD, nephropathy, retinopathy and infection.

LE amputations at least 15x more in diabetics.

Ulcers in diabetics much higher (10%).

Disease in non conventional areas: PFA, infra popliteal



Angiosomes

GRAZIANI ET AL EUR J VASC
ENDOVASC SURG 2007

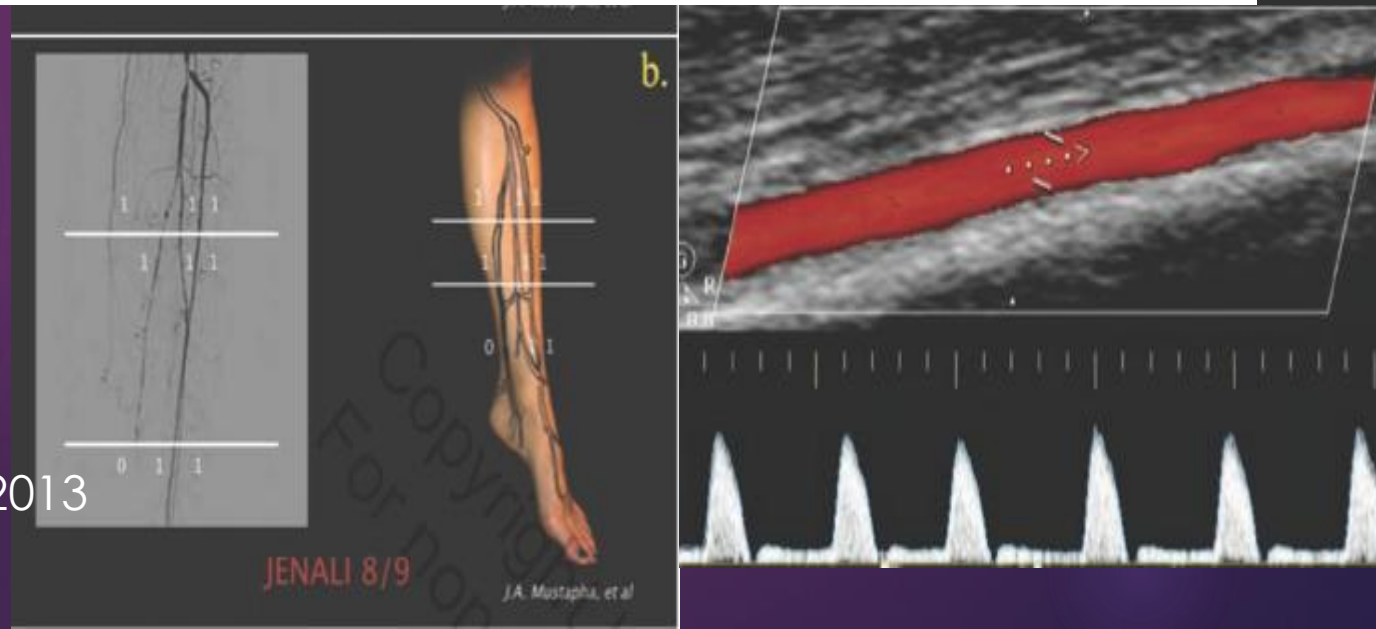
Vascular in wound Care

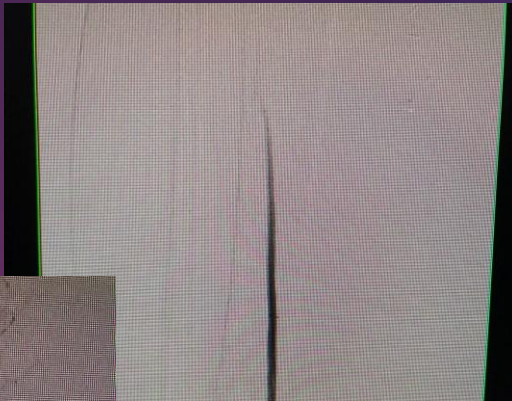
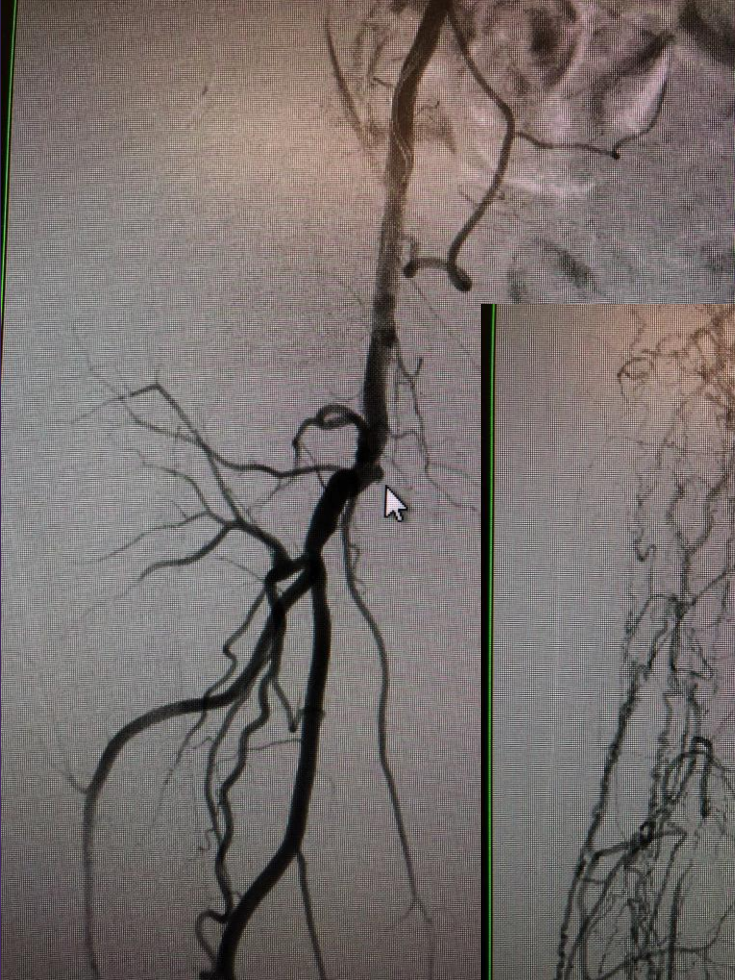
- ▶ To prove that the patient does not have vascular disease: arterial, venous or mixed.
- ▶ Doppler signal only not equal to acceptable flow.
- ▶ Be aggressive.
 - ▶ Both diagnosis and treatment.
 - ▶ Does not mean unnecessary procedures.
 - ▶ Endo, open , combined.
- ▶ Vascular care only is not sufficient care: Adopt or refer.

Peripheral Vascular Disease

Comparison Between Angiographic and Arterial Duplex Ultrasound Assessment of Tibial Arteries in Patients With Peripheral Arterial Disease: On Behalf of the Joint Endovascular and Non-Invasive Assessment of Limb Perfusion (JENALI) Group

Jihad A. Mustapha, MD, Fadi Saab, MD, Larry Diaz-Sandoval, MD, Barbara Karenko, DO,
Theresa McGoff, BSN, Carmen Heaney, BSN, Matthew Sevensma, DO





DM: Capillary Changes



Microcirculatory deficiencies. These abnormalities include a reduction of capillary size, thickening of the basement membrane, and arteriolar hyalinosis.



Impaired endothelial dysfunction: reduction in nitric Oxide synthetase.



Maldistribution of blood flow in diabetes: might contribute to charcot's joints



Vasodilatation is impaired particularly in conditions of stress from trauma and pressure neuropathy, due to the neurovascular response which is dependent on the C-nociceptive nerve fibres and adjacent C fibres, is **impaired, leading to defects in the secretion of substance P, calcitonin gene-related peptide, and histamine.**

DF: Hypoxia



Initially helps initiating healing.



Prolonged hypoxia can cause reperfusion injury and the formation of oxygen radicals.



Hyperglycaemia, metabolic effects of diabetes, hypoxia adversely affects neutrophil and macrophage function

Neuropathy

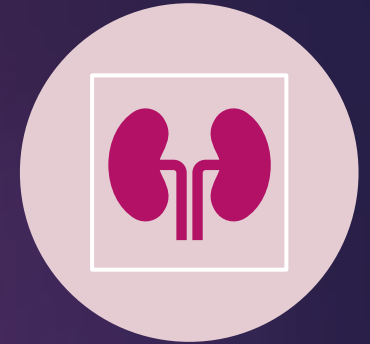
Neuropathy



SOME ARE TIED TO
MICROCIRCULATORY DEFECTS.



MOTOR, SENSORY, AND AUTONOMIC
FIBERS ARE ALL AFFECTED.



SENSORY DEFICITS: THE DIABETIC
PATIENT DOES NOT HAVE PROTECTIVE
SYMPTOMS GUARDING AGAINST
PRESSURE AND HEAT THUS TRAUMA CAN
INITIATE ULCER DEVELOPMENT.

Absence of pain: with abnormal vasodilatory autoregulation, contributes to the pathogenesis of Charcot foot, which further impairs the ability to sustain pressure.

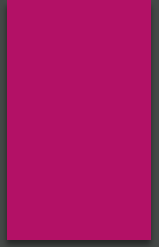
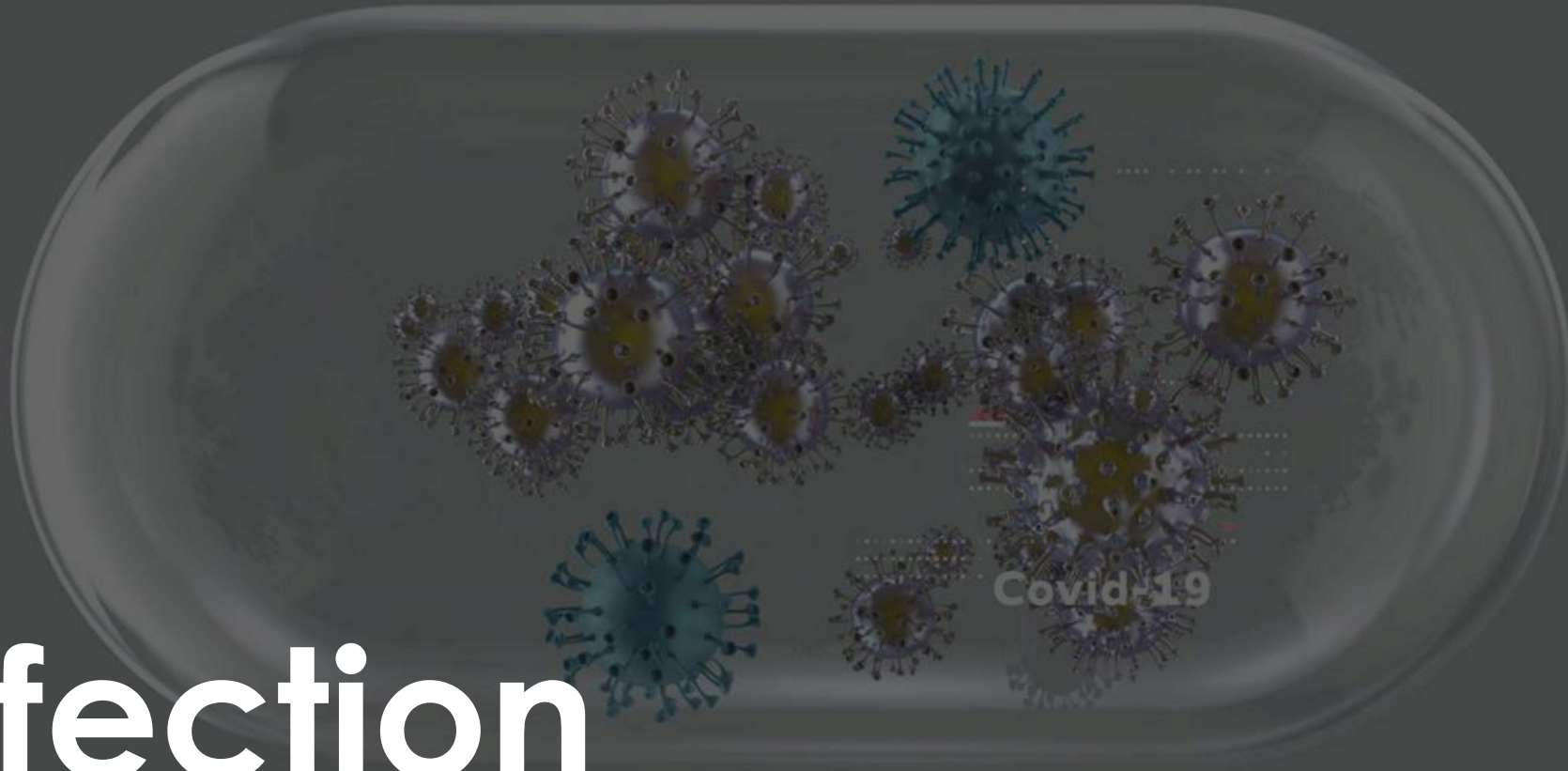
motor fiber abnormalities



Charcot foot

Falanga , lancet 2005

Infection



Diabetic Foot: Infection



Not a stated component of the pathogenic triad for development of diabetic foot ulcers.



Extremely important cause of morbidity and hospitalization, amputation, and impaired healing



Falanga , lancet 2005

DF: Infection



Stress and compressive forces favoring overgrowth of bacteria.



Decreased function of macrophages and neutrophils.

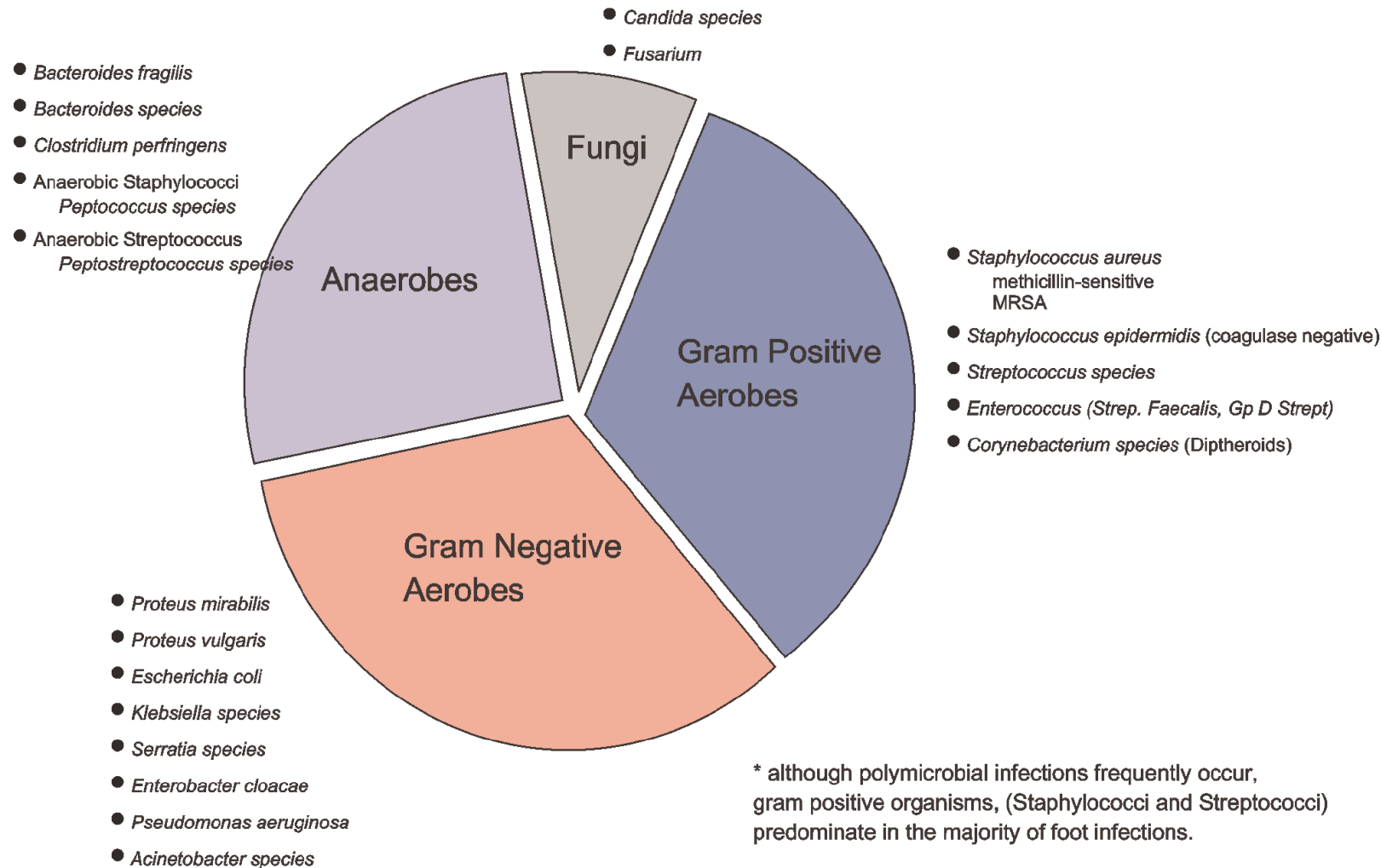


Infection can spread rapidly in diabetic ulcers.



High bacterial burden without the classic signs of infection is also detrimental to healing

Bacterial infection in diabetic infection



Frequent Debridement



Proper debridement involves removal of the necrotic wound bed and callus, which can contribute to increased pressure on the insensate foot.



debridement increased the therapeutic effect of topically applied PDGF.



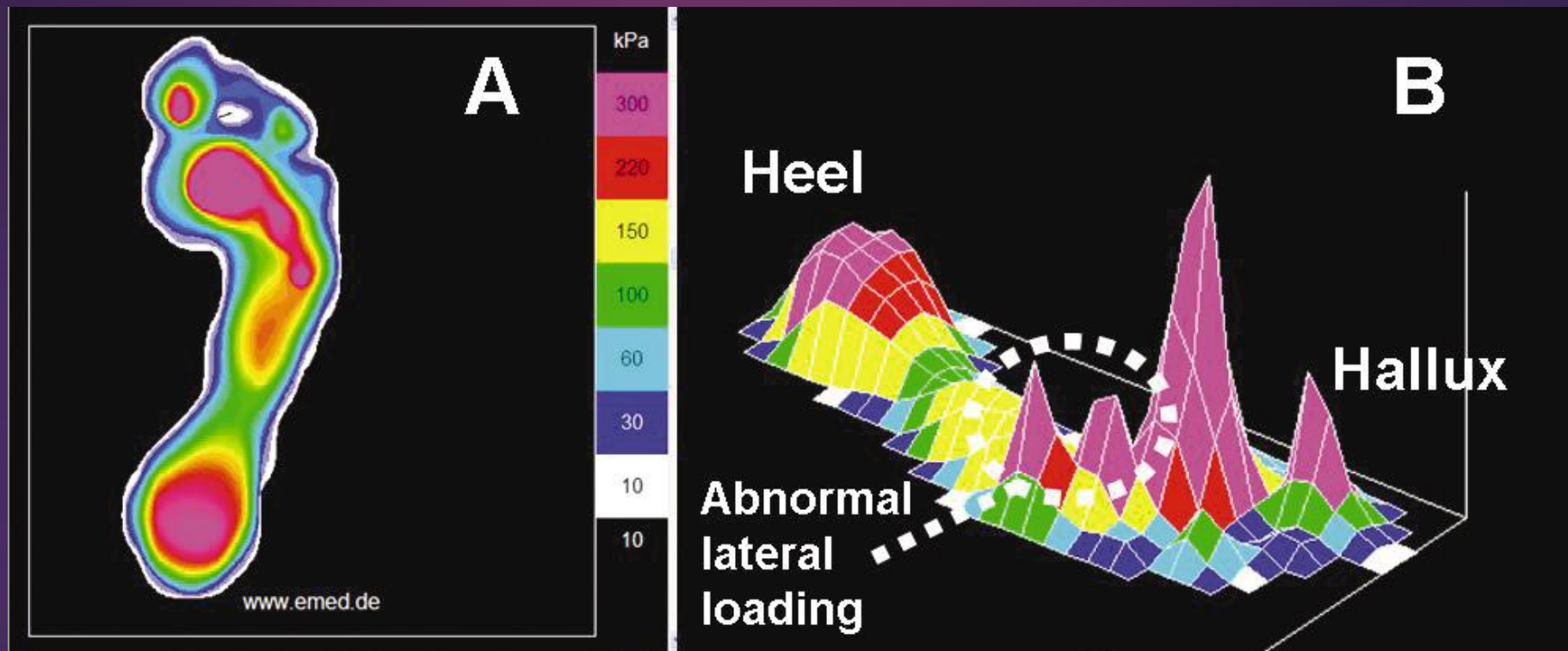
Corrects several cellular and molecular abnormalities

Basics of Treatment in DFU

- ▶ Foot Care
- ▶ Treat infection
- ▶ Revascularize: aggressive
- ▶ Offloading.... Offloading...Offloading



Offloading



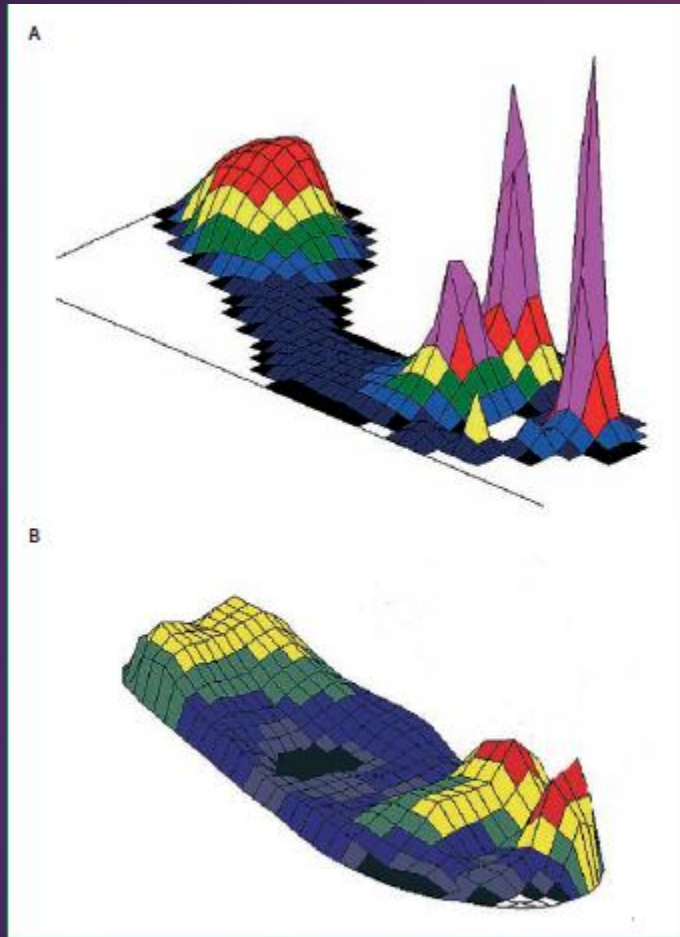
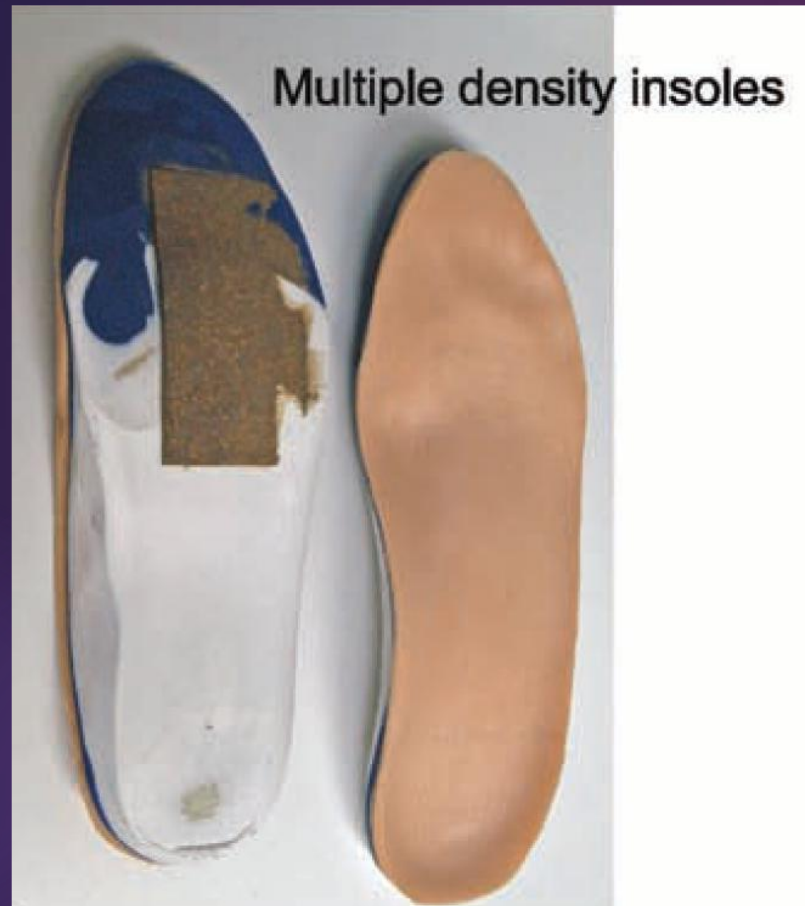


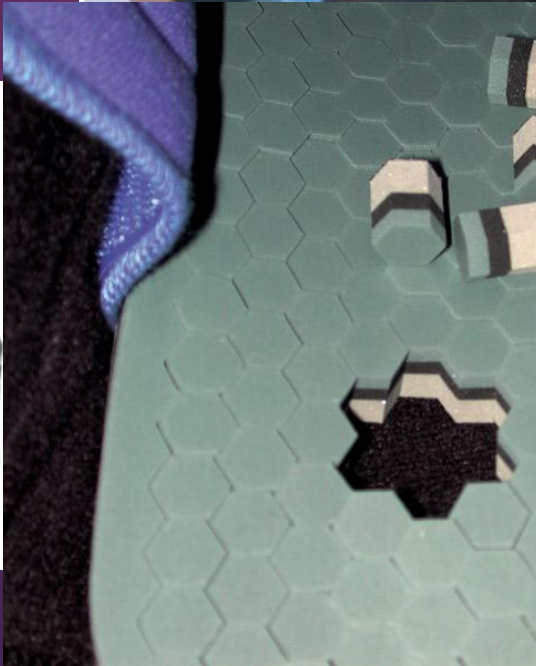
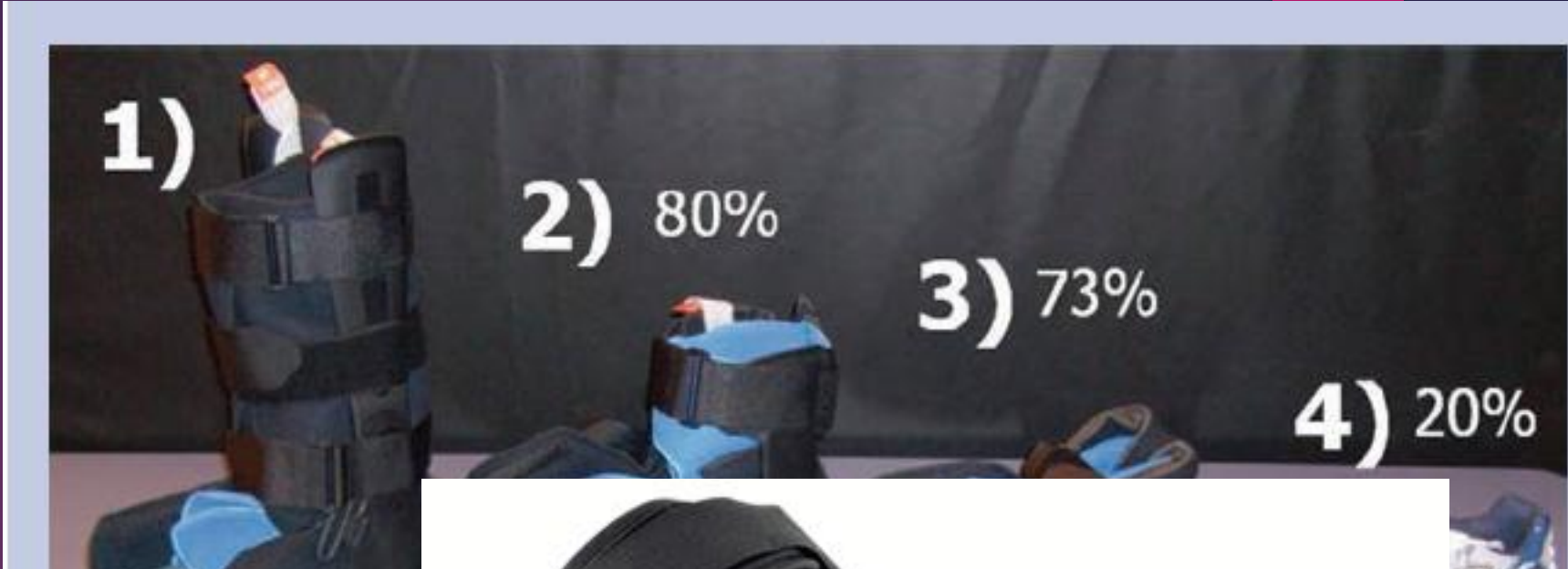
Figure 3: Plantar pressure distribution under the foot during (A) barefoot walking and (B) walking in appropriate therapeutic shoes and custom insoles¹⁸

Peak pressures are more than 1000 kPa in (A) and less than 200 kPa in (B). This patient had previous ulcers at the site of raised pressure under the hallux.

Plantar pressure
distribution during
walking and
After using special
shoes

Cavanagh et al Lancet 2005

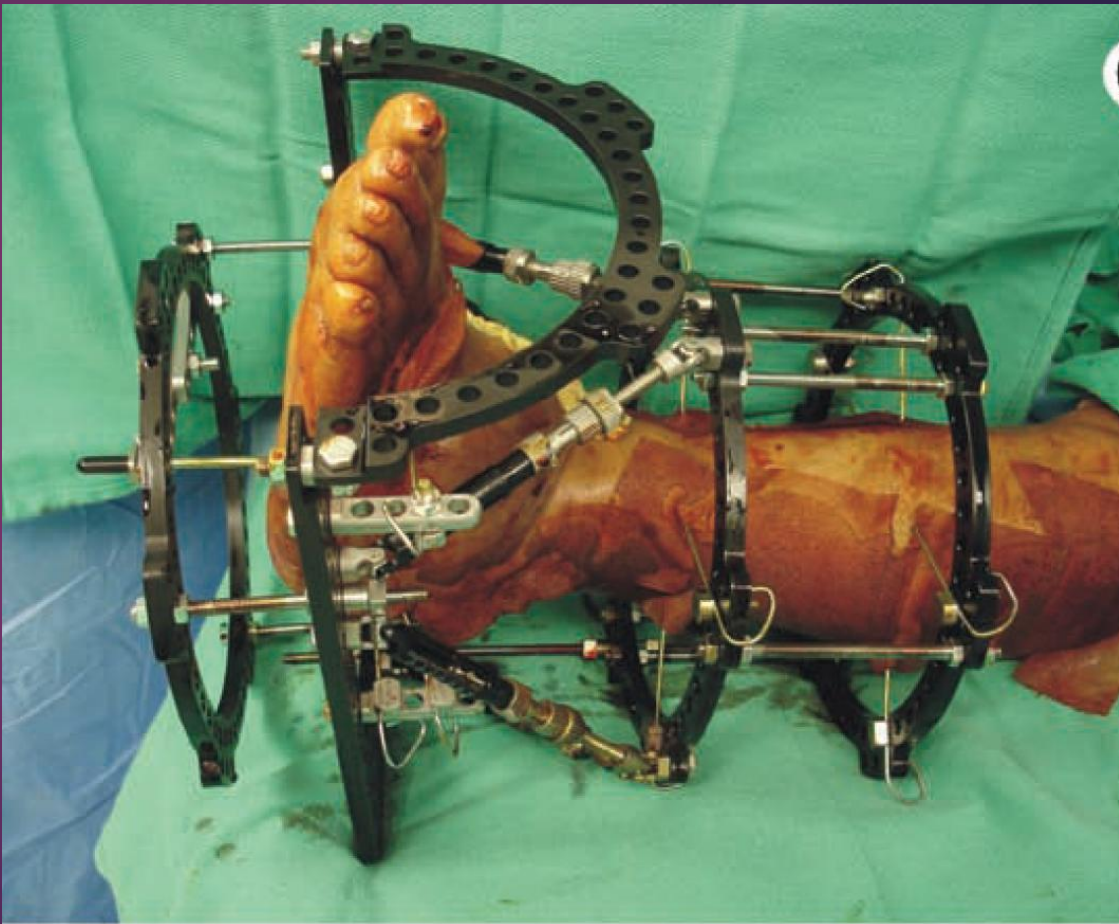




the cast
may in-

Total Contact Cast





HBOT and Diabetic foot Ulcers

Clinical Uses and Therapeutic Effects of Hyperbaric Oxygen







HBOT in Diabetic Ulcers

- ▶ Most of the reports are case series.
- ▶ These reports has consistent message that HBOT works for diabetic patients.

HBOT: Metanalysis (10 studies, 6 nonrandomized)

Reduces the risk of amputation
(odds ratio 0.24, seven studies)

Increases likelihood of wound
healing (odds ratio 10.0, six studies)

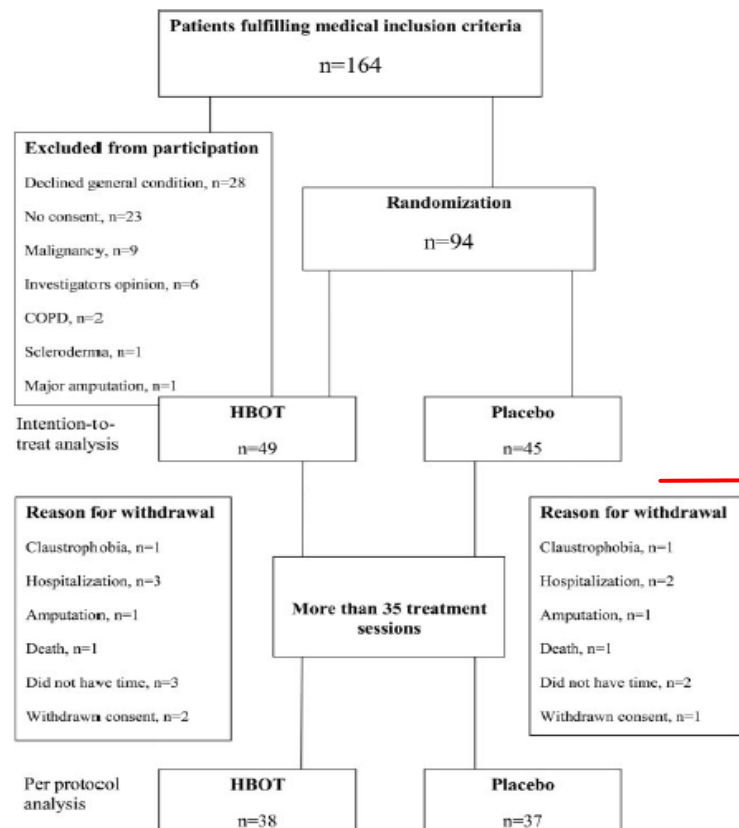
Hyperbaric Oxygen Therapy Facilitates Healing of Chronic Foot Ulcers in Patients With Diabetes

MAGNUS LÖNDAHL, MD¹
PER KATZMAN, MD, PHD¹

ANDERS NILSSON, MD²
CHRISTER HAMMARLUND, MD, PHD³

grade 1 and 2 ulcers. Therefore, the clinical utility of HBOT in treating diabetic foot ulcers was not established. The final

Löndahl and Associates



RESULTS — Ninety-four patients with Wagner grade 2, 3, or 4 ulcers, which had been present for >3 months, were studied. In the intention-to-treat analysis, complete healing of the index ulcer was achieved in 37 patients at 1-year of follow-up: 25/48 (52%) in the HBOT group and 12/42 (29%) in the placebo group ($P = 0.03$). In a sub-analysis of those patients completing >35 HBOT sessions, healing of the index ulcer occurred in 23/38 (61%) in the HBOT group and 10/37 (27%) in the placebo group ($P = 0.009$). The frequency of adverse events was low.

Diabetes Care 33:998–1003, 2010

Figure 1—Study flow chart of the HODFU study. COPD, chronic obstructive pulmonary disease.



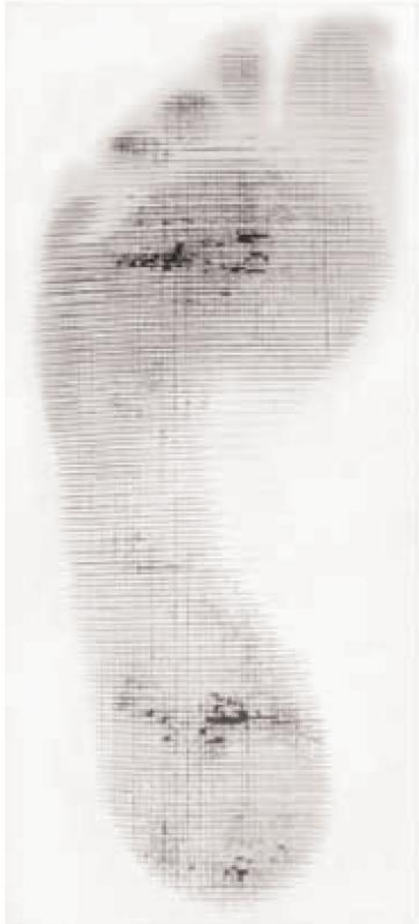






Amputation Prevention

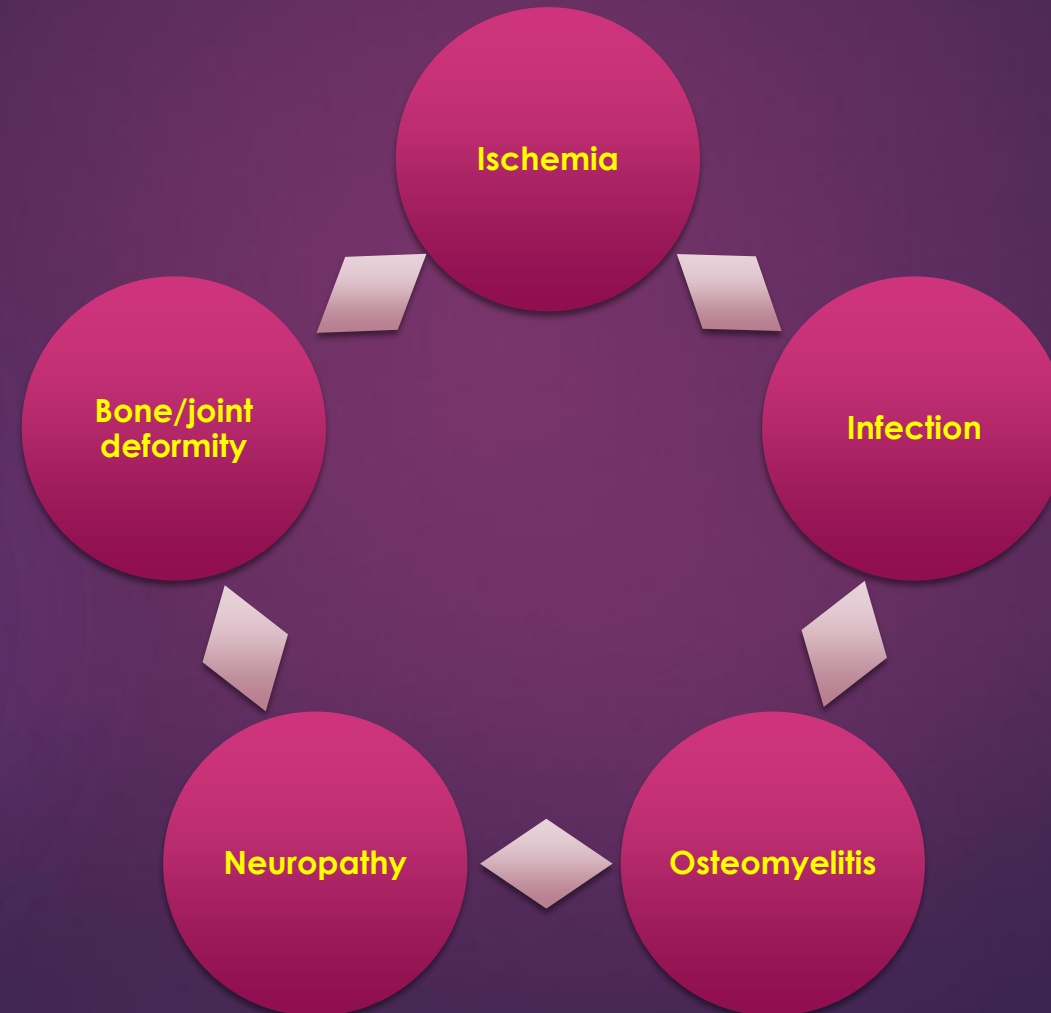
Amputation Prevention Program



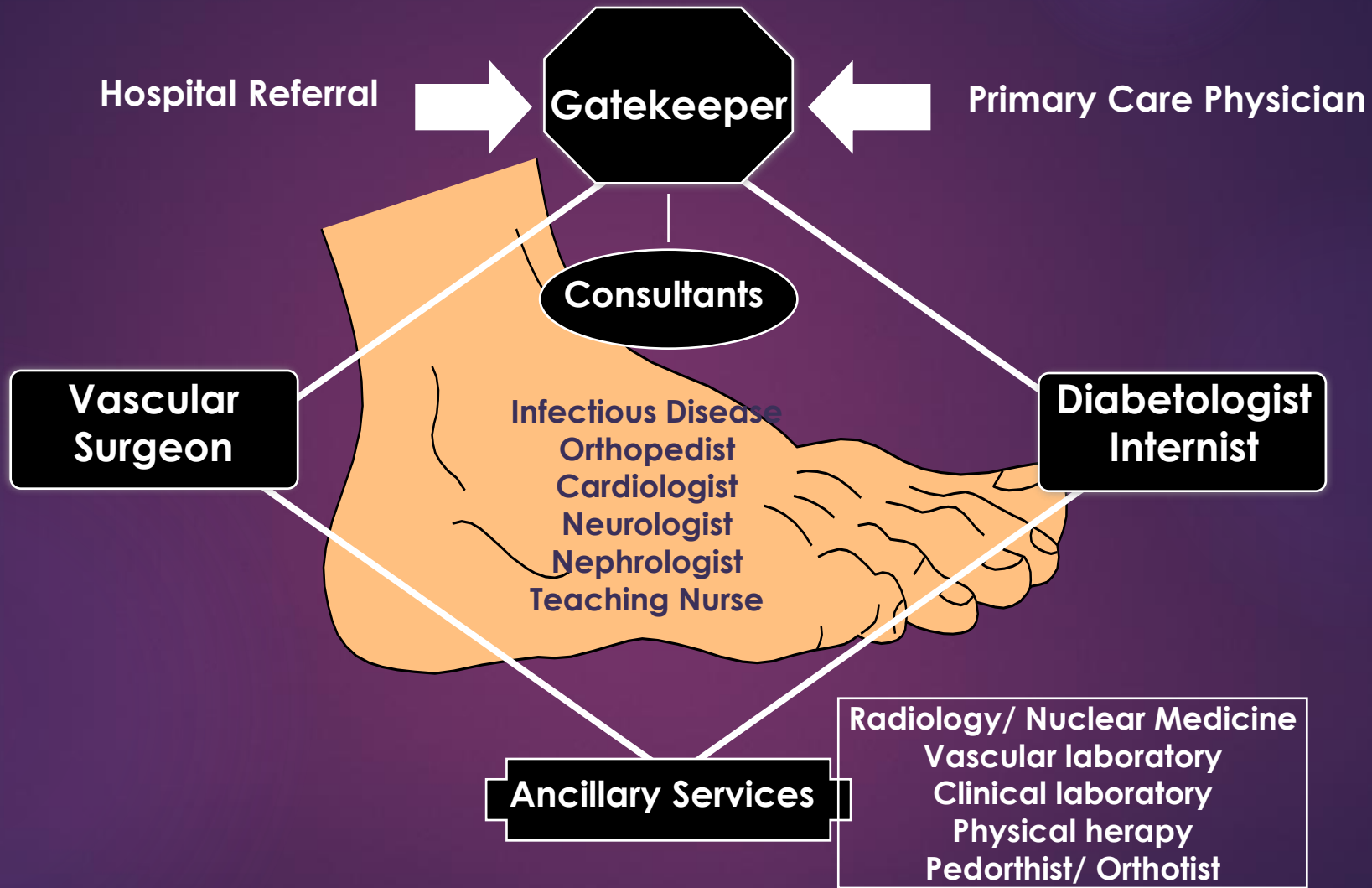
1. Podiatric Foot Care
 - Regular visits, examinations, and footcare
 - Risk assessment
 - Early detection and treatment of new lesions
2. Protective Shoes
 - Adequate room to protect from injury
 - Well cushioned walking sneakers
 - Extra depth or custom-molded shoes
 - Shoe modifications as needed
3. Pressure Reduction
 - Cushioned multiple density insoles
 - Custom orthotic devices or braces
 - Padded hosiery
 - Pressure measurements - computerized or pressure sensitive mat
4. Prophylactic Surgery
 - Correct structural deformity: hammertoes, bunion, exostoses
 - Prevent recurrent ulcers over deformities
5. Preventive Education
 - Patient education - need for daily inspection & necessity for early intervention
 - Physician education - significance of foot lesions, importance of regular foot examinations, & current concepts of diabetic foot management

Diabetic Foot

Multifactorial Problem



Team Approach to Amputation Prevention



MDT in Wound Care

- Utilize standardized protocols specific to wound etiology
- Evidence- based research consistent with standard of care
- Allows for routine ordering of diagnostics: not to miss pathology especially arterial disease and more important venous disease.

Frequent removal of biofilm and debridement will accelerate healing

Protocols will improve care, reduce time to heal, improve access to necessary care, reduce readmission and leads to patient better satisfaction

Gottrup F, et al, Arch Surg, 2001
Chen Y, Medicine 2015

MDT approach in DFU

Improved wound healing

Reduced healing time

Reduction in all cause mortality.

Reduction in minor amputation

Reduction in major amputation

Presence of a team leader in the MDT reduced major amputations in comparison to other organizational strategy

Multidisciplinary Wound Teams

A systemic review of 33 studies:

- ▶ Medical and Surgical providers
- ▶ Larger teams require a champion with defined roles
- ▶ Systematic referrals process and clinical pathways
- ▶ Key elements to address:
 - ▶ Glycemic control
 - ▶ Local wound management
 - ▶ Vascular disease
 - ▶ infection

94% of the studies reported reduction in major amputation after implementation of a multidisciplinary team

Multidisciplinary wound care vs Limb Salvage Program

- ▶ Vascular focused in LSP
- ▶ Greater integration needed in multidisciplinary wound care centers : Vascular, orthotists, podiatry/orthopedics, plastic surgery, infectious disease, internists, wound specialists...etc.

Kim P et al, JVS, 2013

Wound Care within a Vascular Service



64% increase in infra popliteal revascularization.



More limb salvage



Significant reduction in major amputations

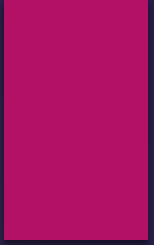


Improved mortality in patients with major amputations



Improved management of patients with wounds and critical limb ischemia independent of the revascularization practices which did not change

Flores AM et al, J Vasc Surg 2019
Qingwen K, JVS 2025



Integration otherwise Amputation

Gatekeeper

Wound Consultation



Interprofessionally

Imaging

ID

Podiatry

OT/PT

Orthotics

Vascular

Patient In

Provider/
Wound
Center

APP

ECF

Hospital

Home Care

Home

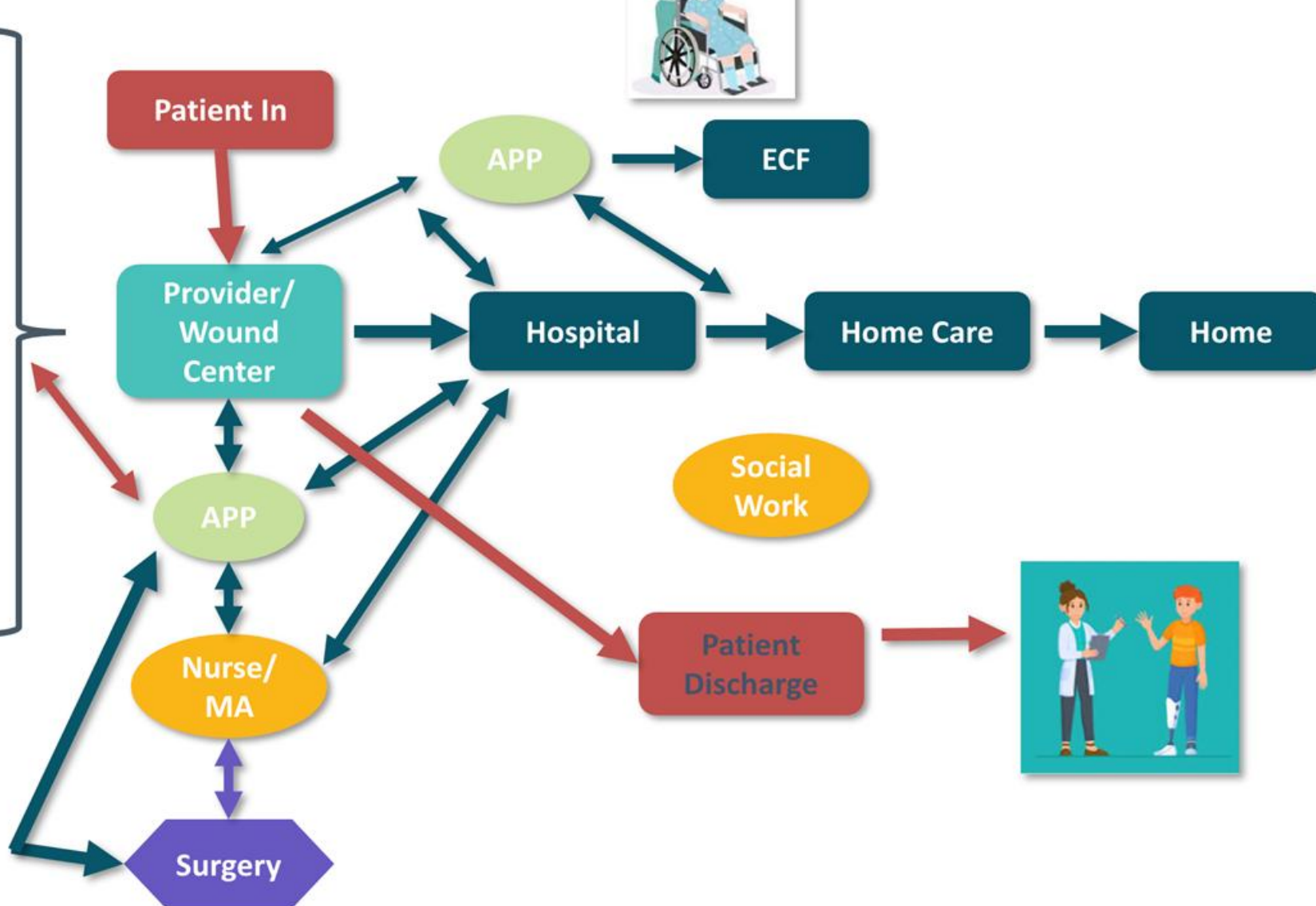
APP

Social
Work

Nurse/
MA

Patient
Discharge

Surgery





Thank you