# Harmful Effects of Hyperglycemia

- Increased capillary basement membrane thickening causing microvascular problems
- Impairment of phagocytosis (ability to fight infections)
- Abnormally high levels of minor (glycosylated) proteins: advanced glycosylated end products (AGES) that interfere with the protein's normal physiology
- Glucose metabolized to sorbitol via the polyol pathway
- Increased aldose reductase
- Faulty lipid metabolism yields hypercholesterolemia and hypertriglyceridemia
- Increased neonatal morbidity and mortality

*OXIDATIVE STRESS with increased levels of Reactive Oxygen Species (ROS) results from 4 major pathways*

- Increased blood pressure
- Hemorrheologic factors affected adversely:
  - Increased platelet adhesiveness
  - Increased serum fibrinogen levels
  - Increased blood viscosity
  - Decreased red blood cell flexibility
  - Increased coagulation factors like plasminogen activator inhibitor-1 (PAI-1)
  - Increased lipoprotein A
  - Increased CRP (INFLAMMATION)
- Increased activation of some isoforms of protein kinase C (PKC) causing reduced vascular contractility & oxidative stress with damage to endothelium
  - Increased sialic acid levels in the blood
  - Increased Coronary Artery Disease
  - Increased dental cavities and gum disease
  - Increased weight
  - Increased incidence of cataracts
  - Skin disorders
  - DEPRESSION

# The Polyol Pathway

**Glucose + NADPH** $\xrightarrow{\text{Aldose Reductase}}$ **Sorbitol + NADP**

**Sorbitol + NAD** $\xrightarrow{\text{Sorbitol Dehydrogenase}}$ **Fructose + NADH**

# Dyslipidemias and Diabetes

- Enhanced VLDL Secretion
- Increased Small Dense LDL Production
- Hypertriglyceridemia
- Decreased HDL Secretion

- TREATMENT: STATINS (Crestor or Lipitor)

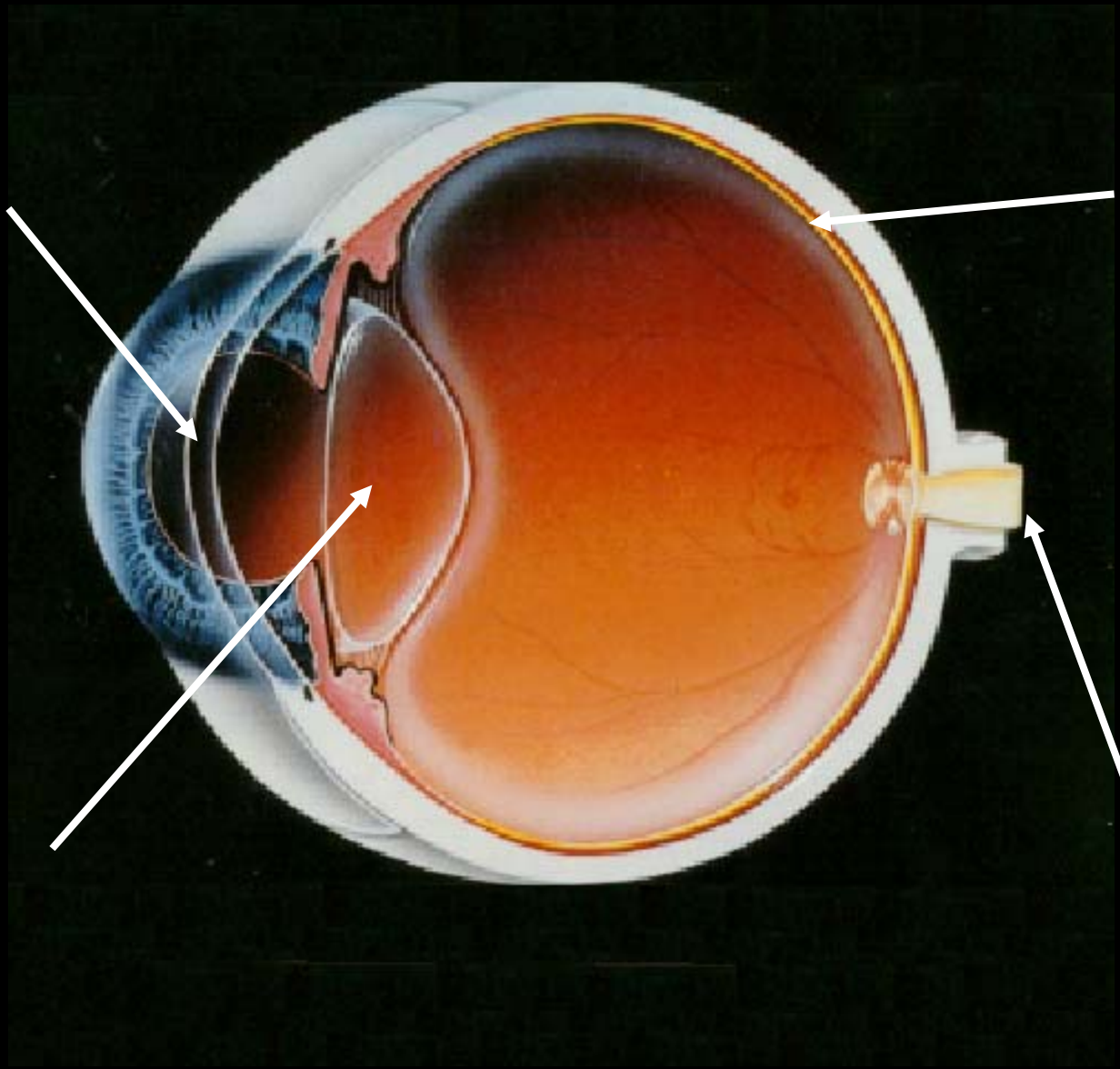
# Harmful Effects of Hyperglycemia (cont.)

- Increased activation of some isoforms of protein Kinase C (PKC) causing reduced vascular contractility and oxidative stress
- Increased sialic acid levels in the blood
- Increased coronary artery disease
- Increased dental cavities and gum disease
- Increased weight
- Increased incidence of cataracts & glaucoma
- Numerous other problems like skin problems, ED, depression, foot disorders

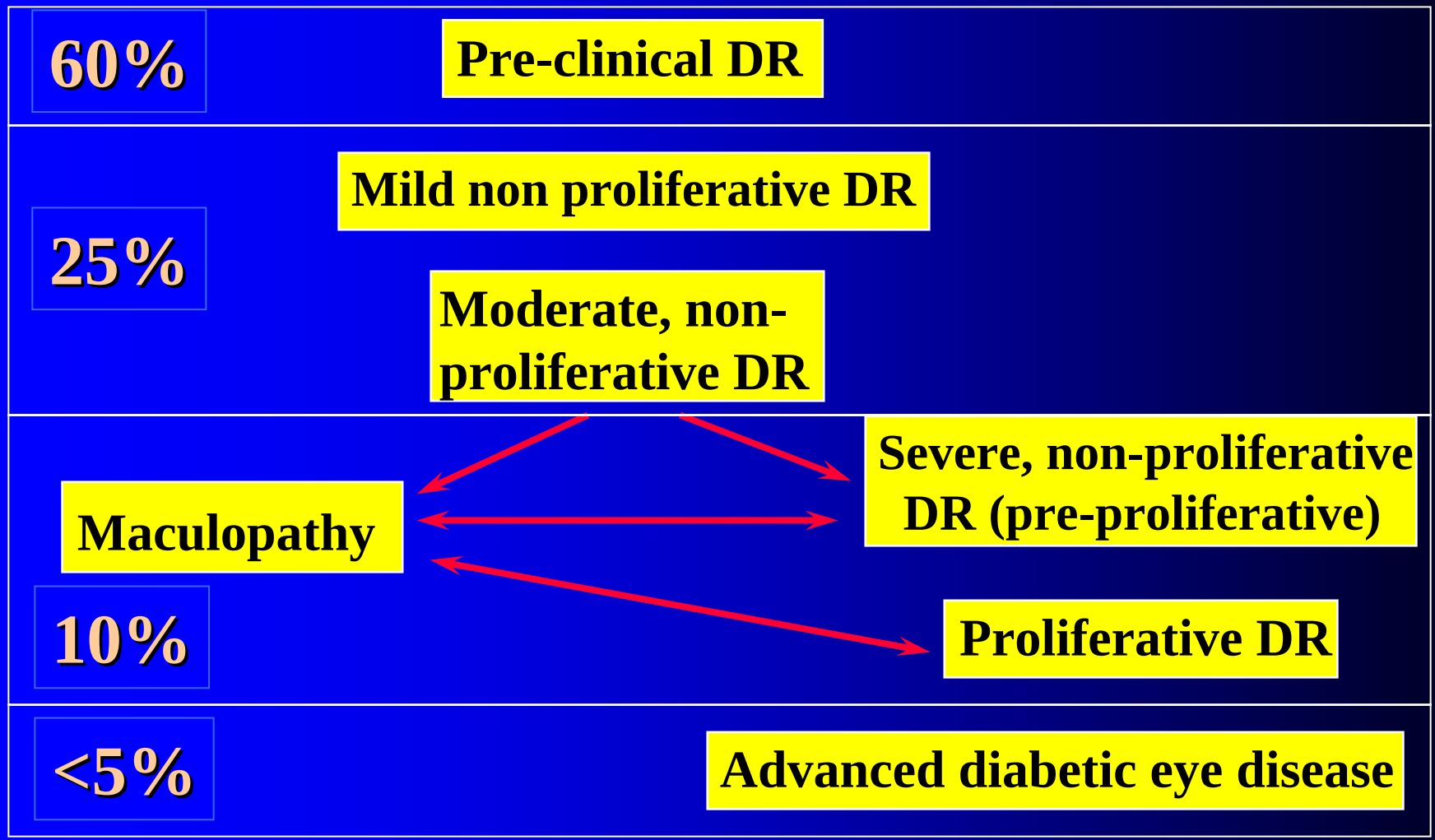
# Treating Diabetes Complications

- Retinopathy: Normalize Blood Glucose, Annual Dilated Pupil Exams, Laser Therapy and Vitrectomy if needed
- Nephropathy: Normalize Blood Glucose, ACE Inhibitors
- Neuropathy: Normalize Blood Glucose, Capsaicin, Gabapentin, Lyrica, Anti-Depressants (Cymbalta), Preventative foot care
- Cardiovascular disease: normalize glucose, statins, ACE-I, aspirin, anti-oxidants

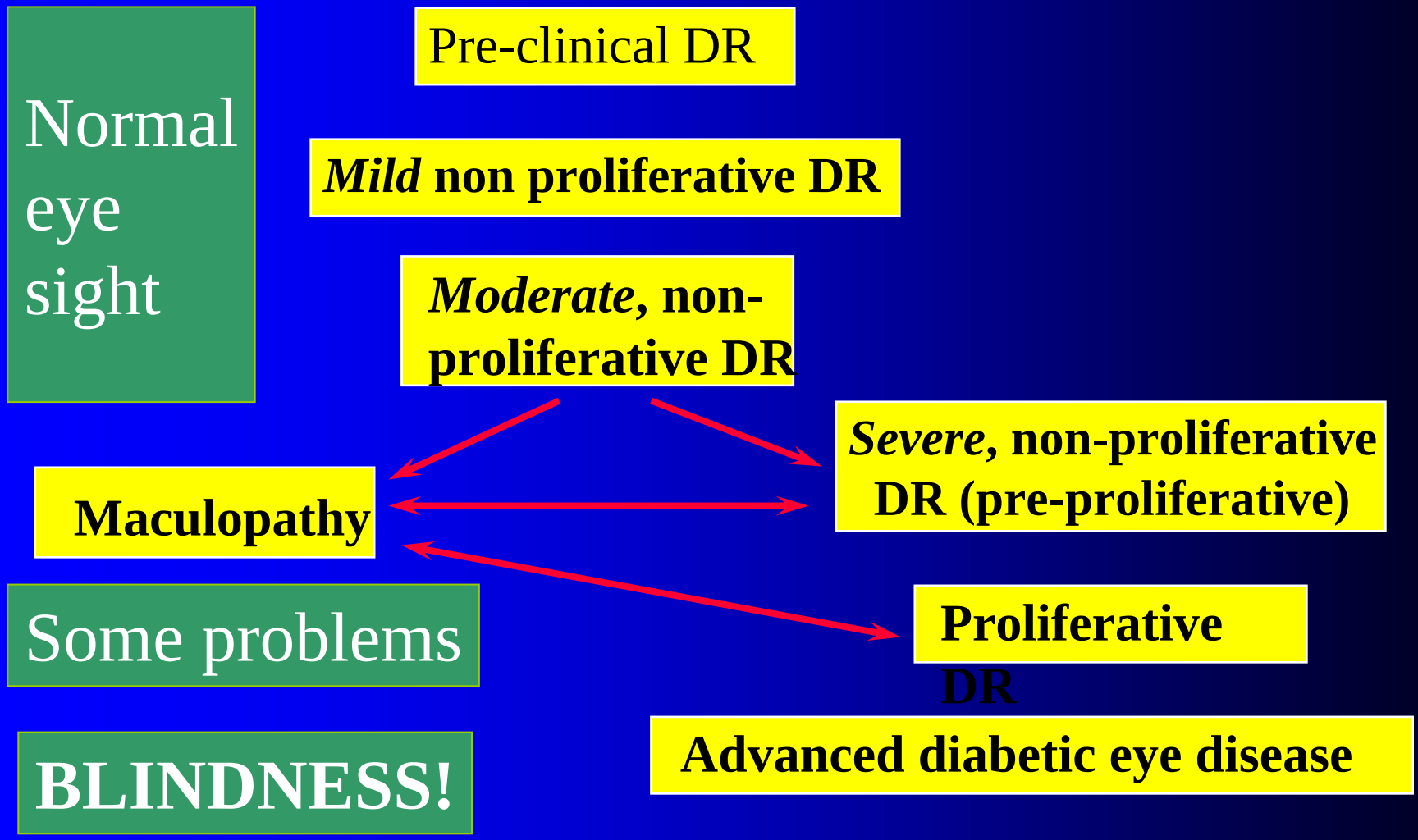
# The Human Eye



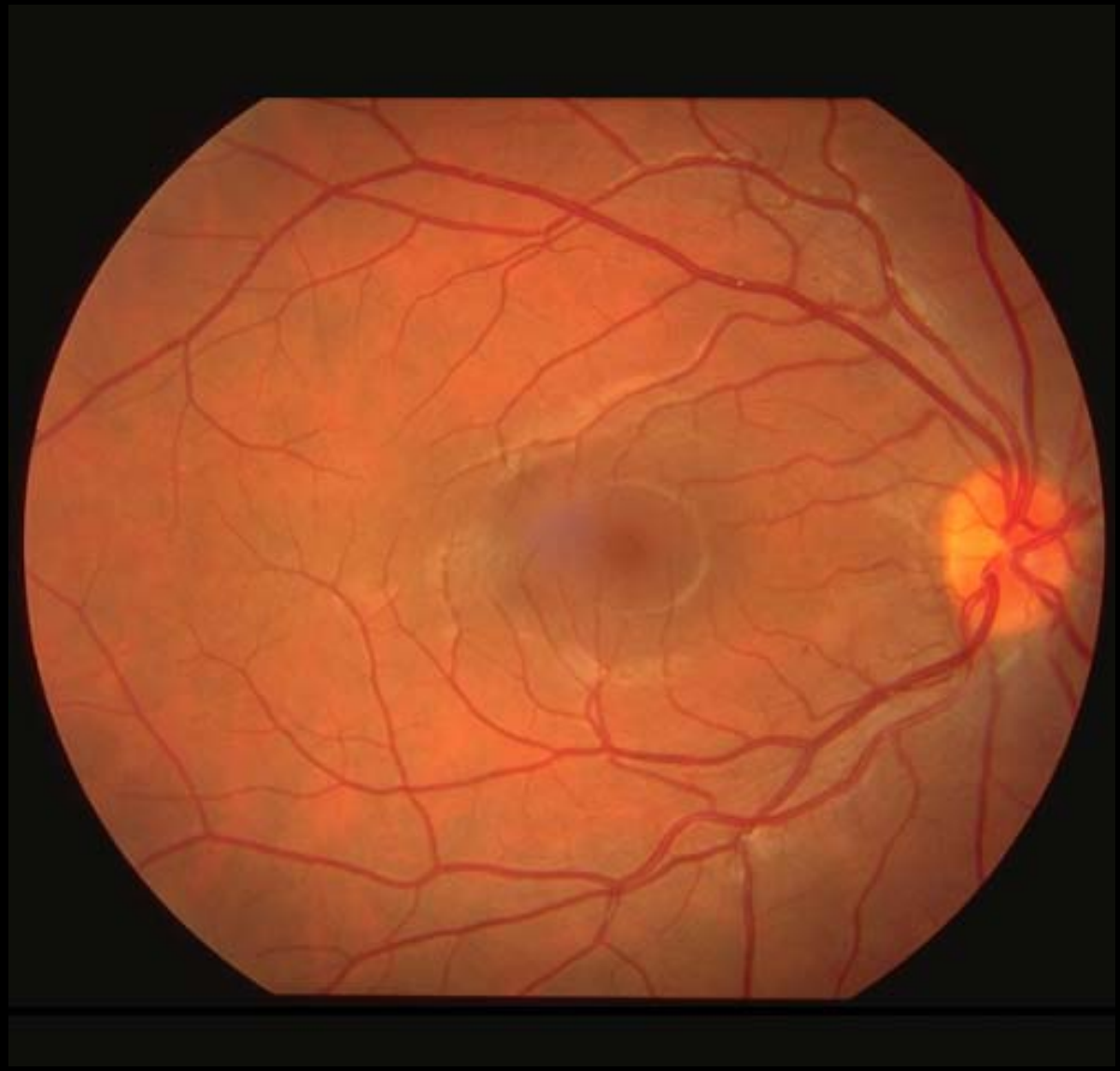
# Natural History of Diabetic Retinopathy



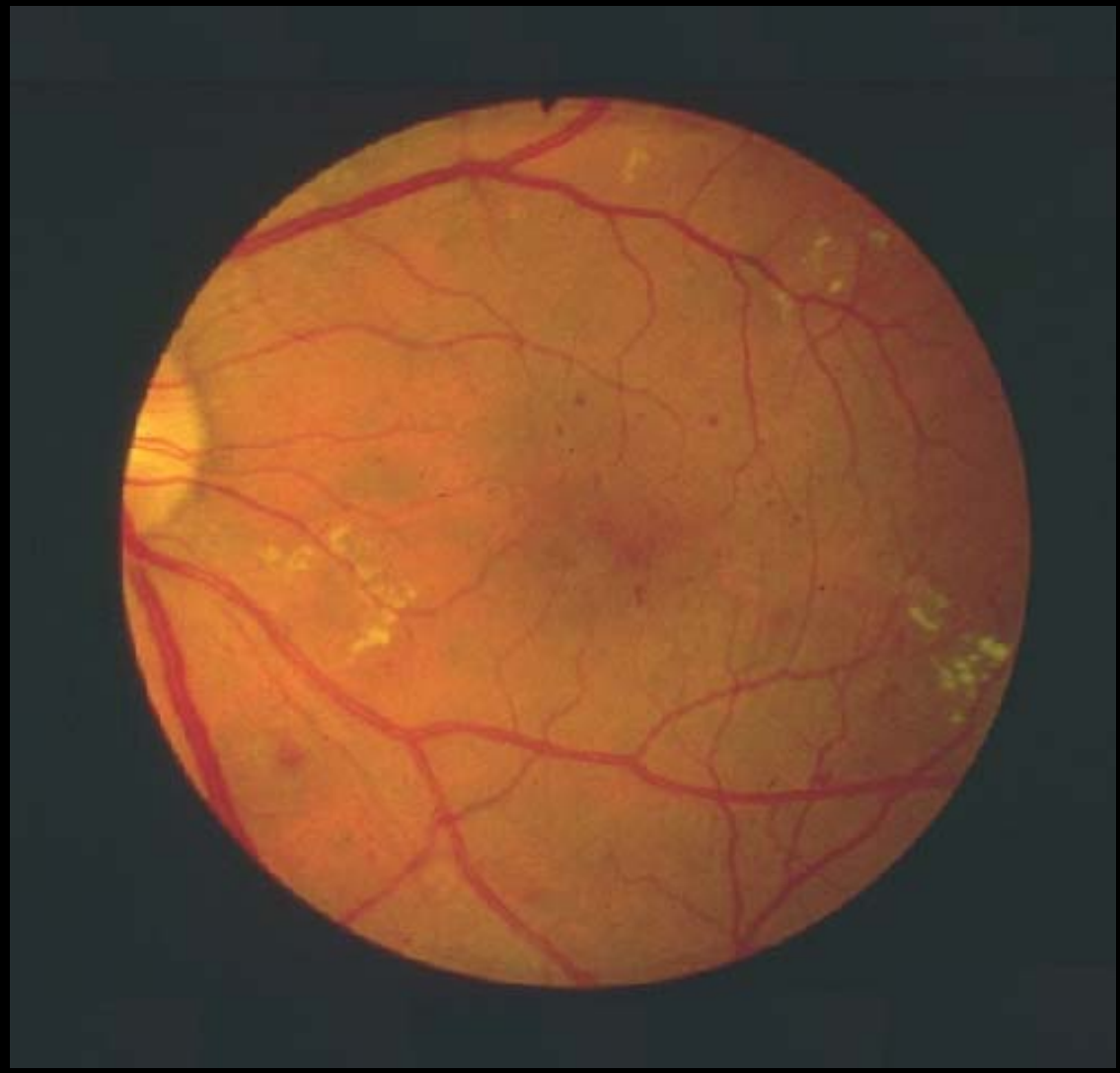
# Natural History of Diabetic Retinopathy



# Pre-clinical Diabetic Retinopathy

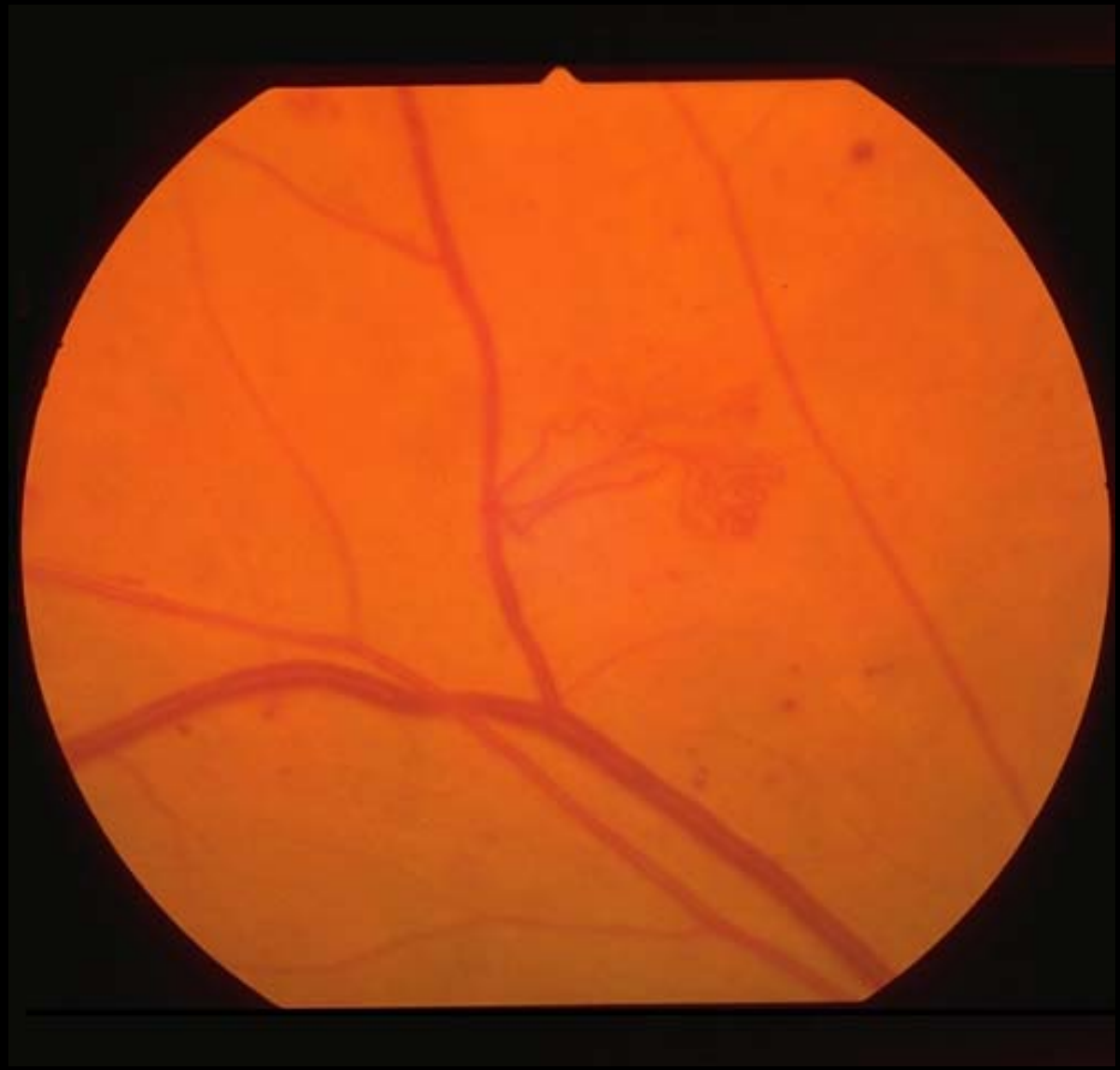


# Moderate NPDR:
# Red Lesions and Hard Exudates



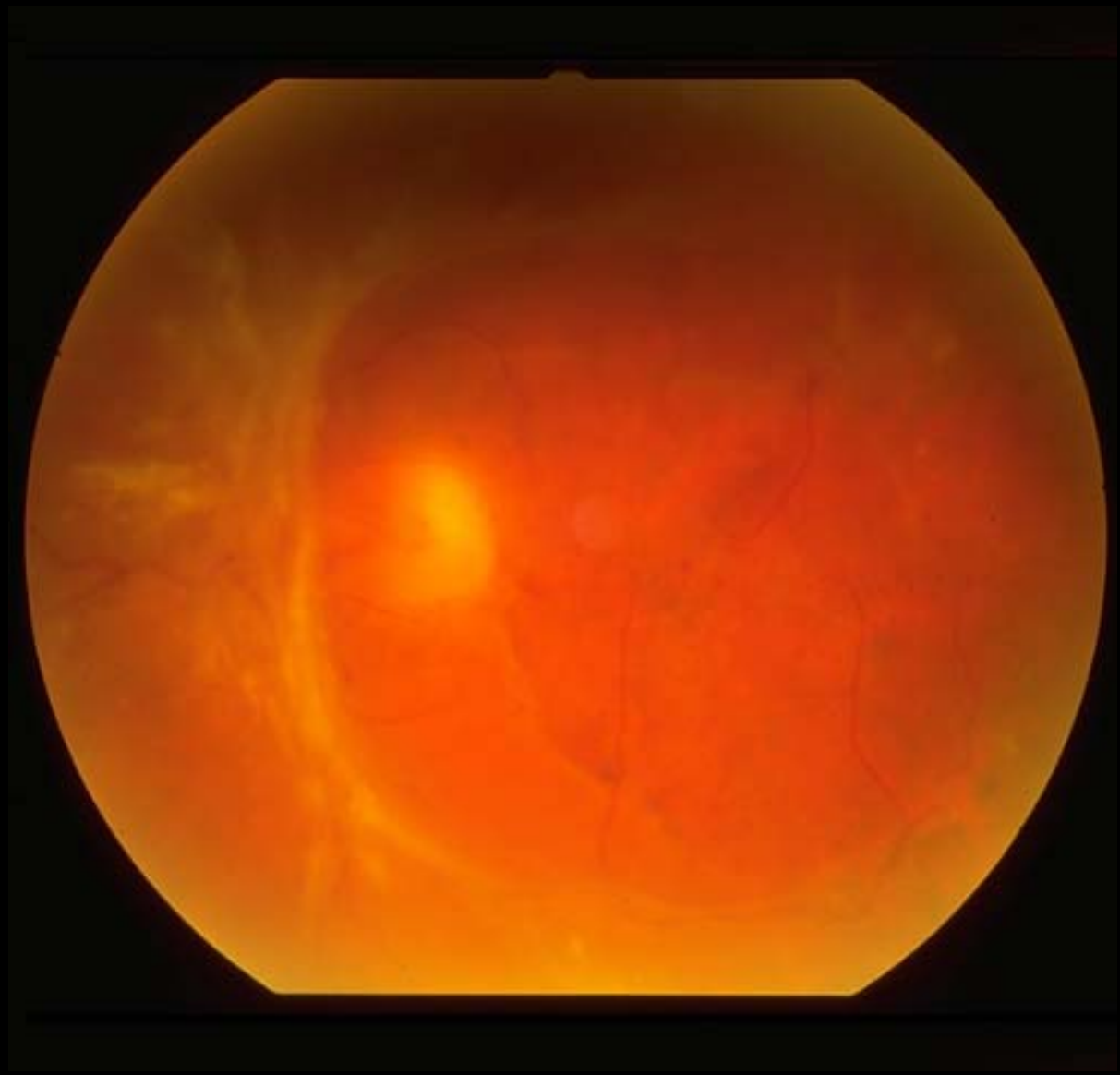
# Maculopathy

# PDR: New Vessels Elsewhere



# PDR: Vitreous Haemorrhage

# ADED: Retinal Detachment



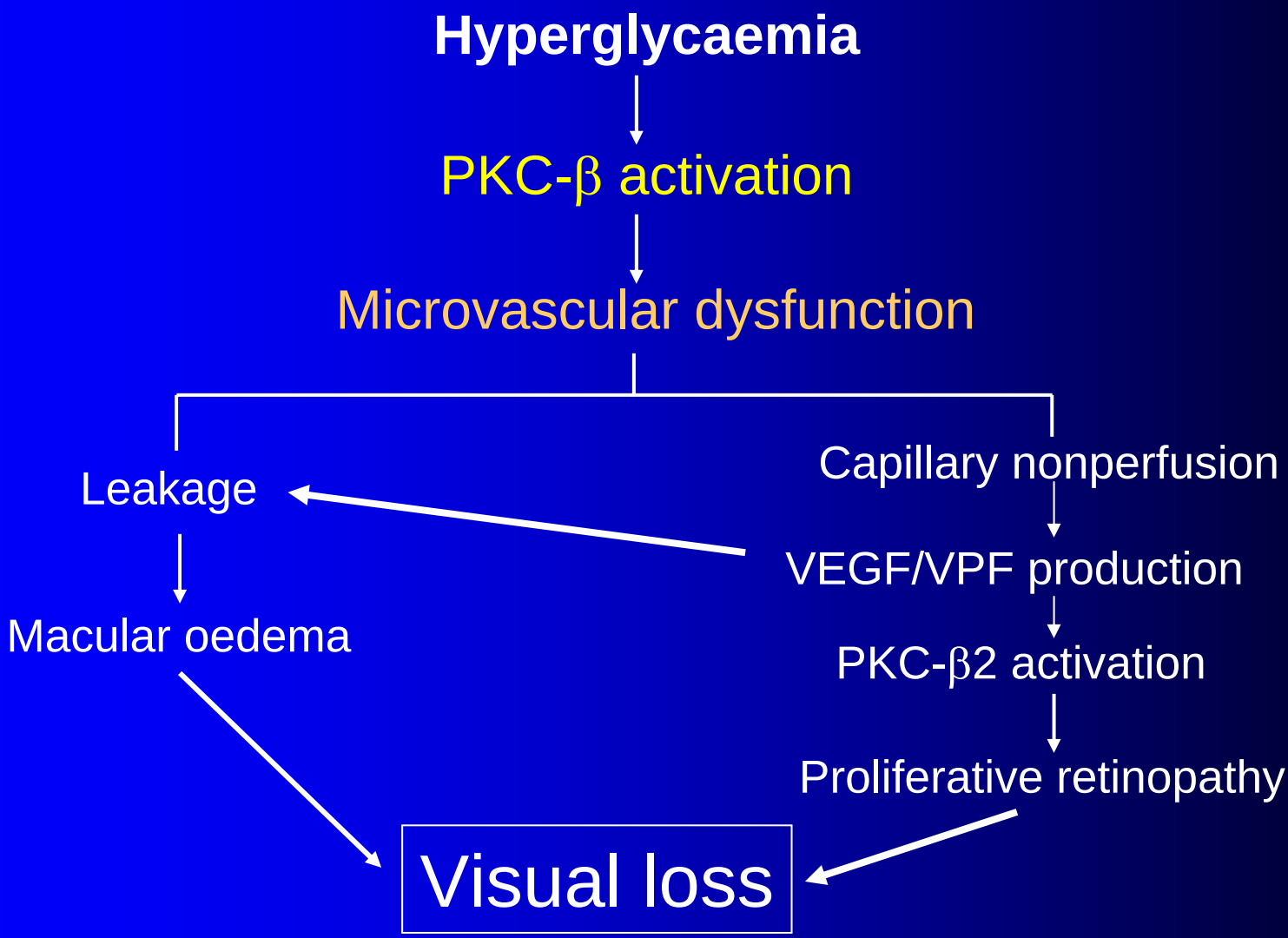
# Treatment of DR:

- **Photocoagulation (laser therapy):**
  - **Panretinal (proliferative)**
  - **Focal and/or grid (maculopathy)**
  - **Vitrectomy**
- **Medical:**
  - **Metabolic control**
  - **Blood pressure control**

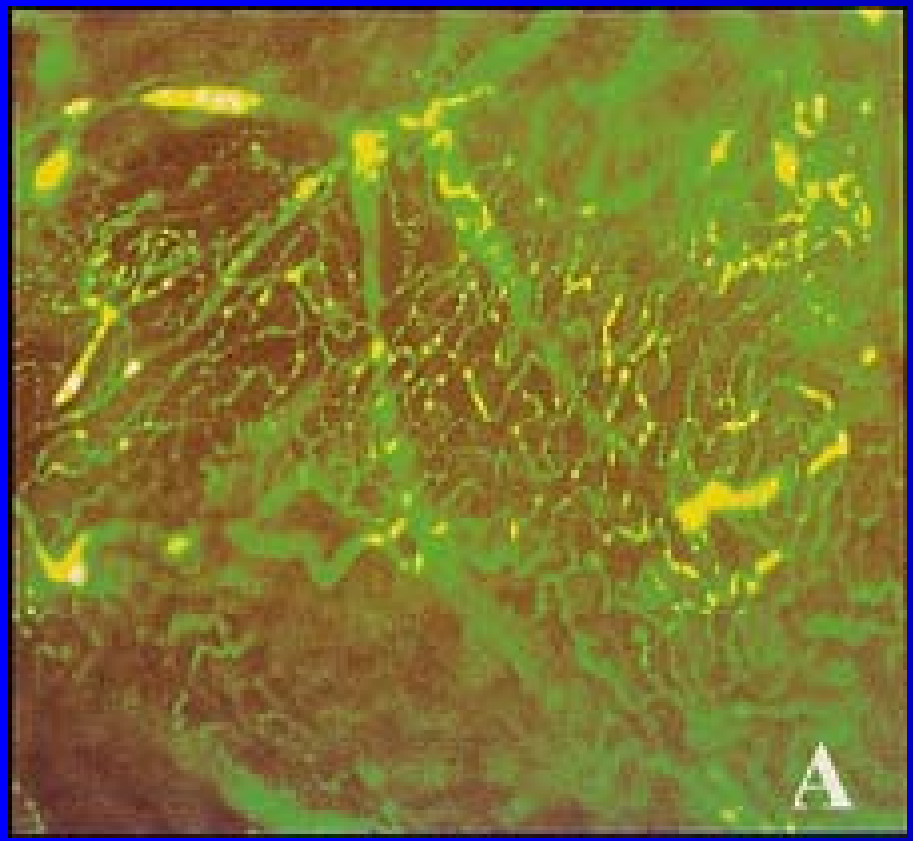
# What should a person with diabetes do to prevent blindness?

- Keep blood glucose values as close as possible to non-diabetic levels [below 6.1 mmol/l (110 mm/dl) and below 7.8 mmol/l (140 mm/dl) after meals]
- Keep blood pressure below 130/80 mmHg
- HAVE HIS/HER EYES CHECKED ONCE A YEAR for diabetic retinopathy

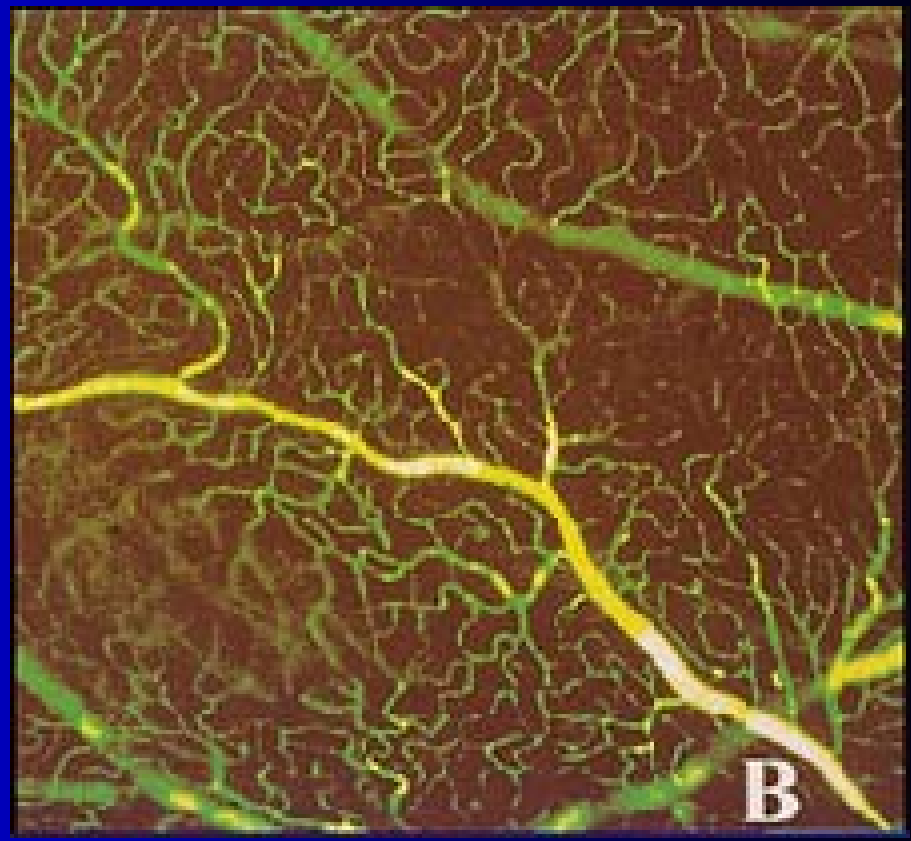
# Diabetic Microvascular Dysfunction



# VEGF vs. Control

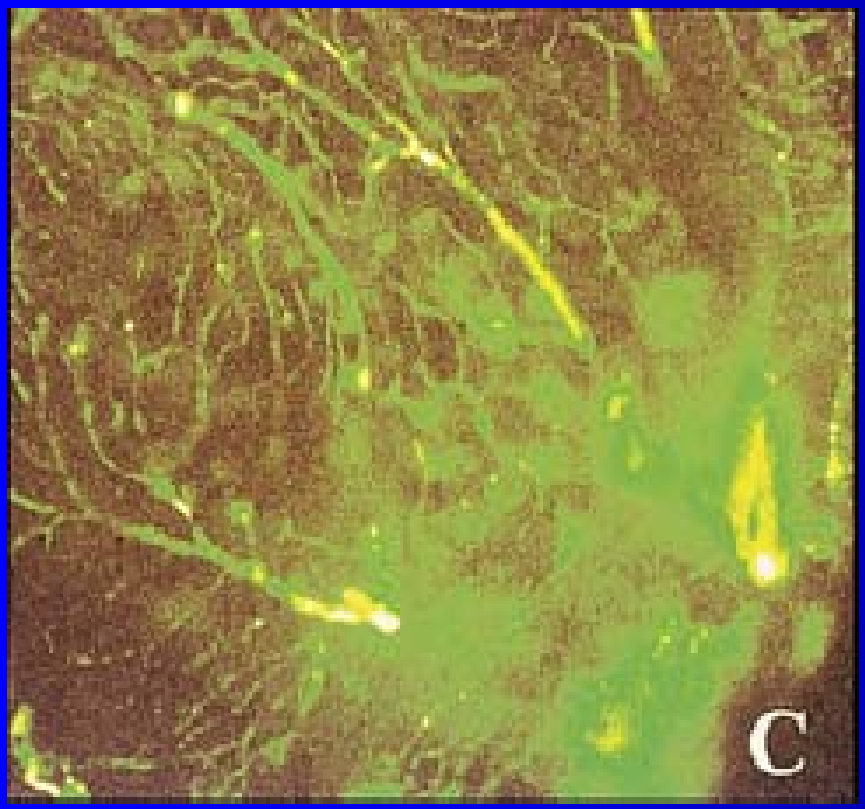



**VEGF**

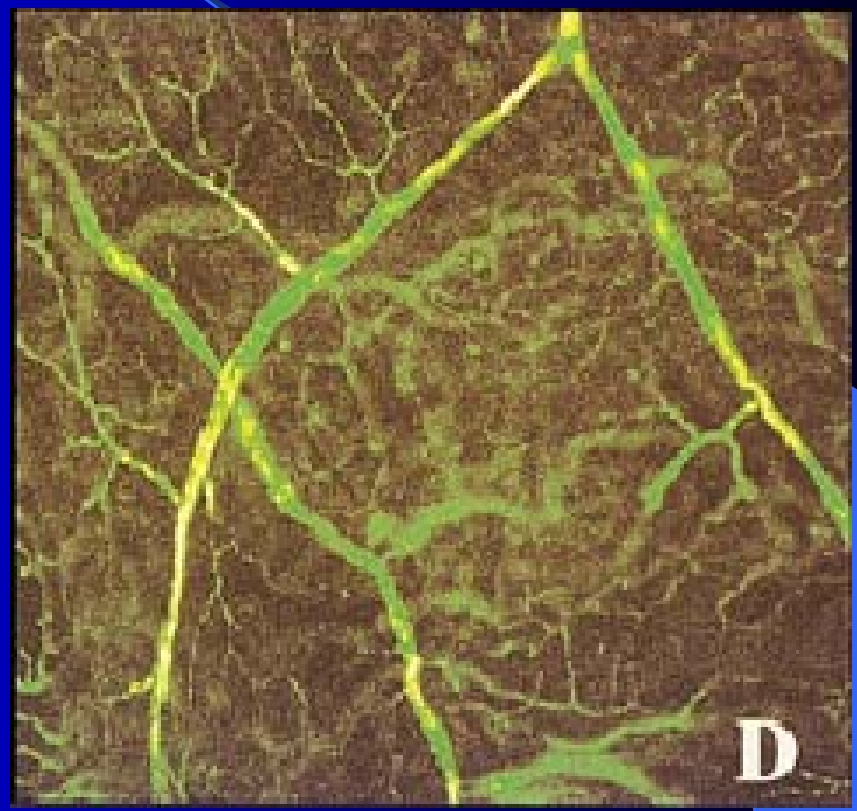



**Control**

# VEGF and PKC-ß Inhibition




VEGF




VEGF+PKCßi

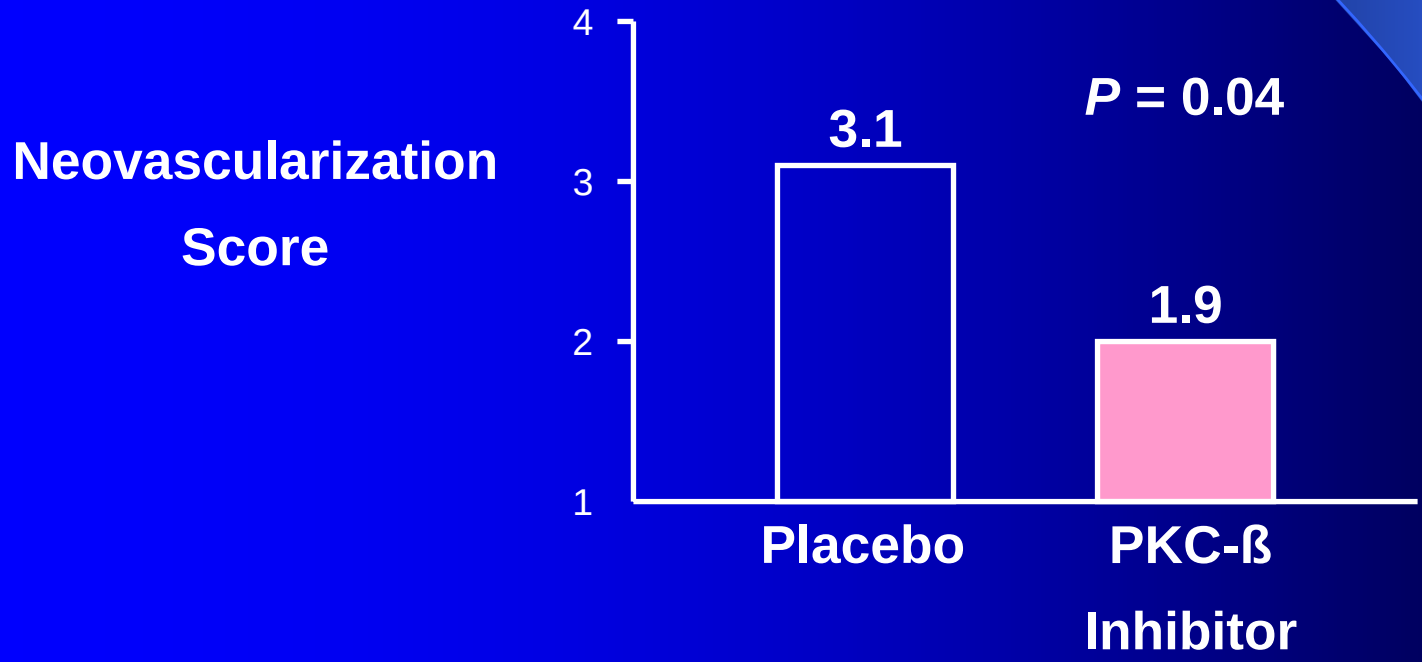
# VEGF and PKC-ß

- PKC activation is critical step in hypoxic and hyperglycemic stimulation of VEGF expression
- PKC-ß activation is required for VEGF to induce its proliferative and permeability effects

# PKC-ß Inhibition

- Selective inhibition of PKC-ß has been shown to block hyperglycemia-induced expression of VEGF at multiple points along the pathway
- Results in ameliorating effect on diabetes-induced vascular complications

# Effect of PKC-ß inhibition on Neovascularization



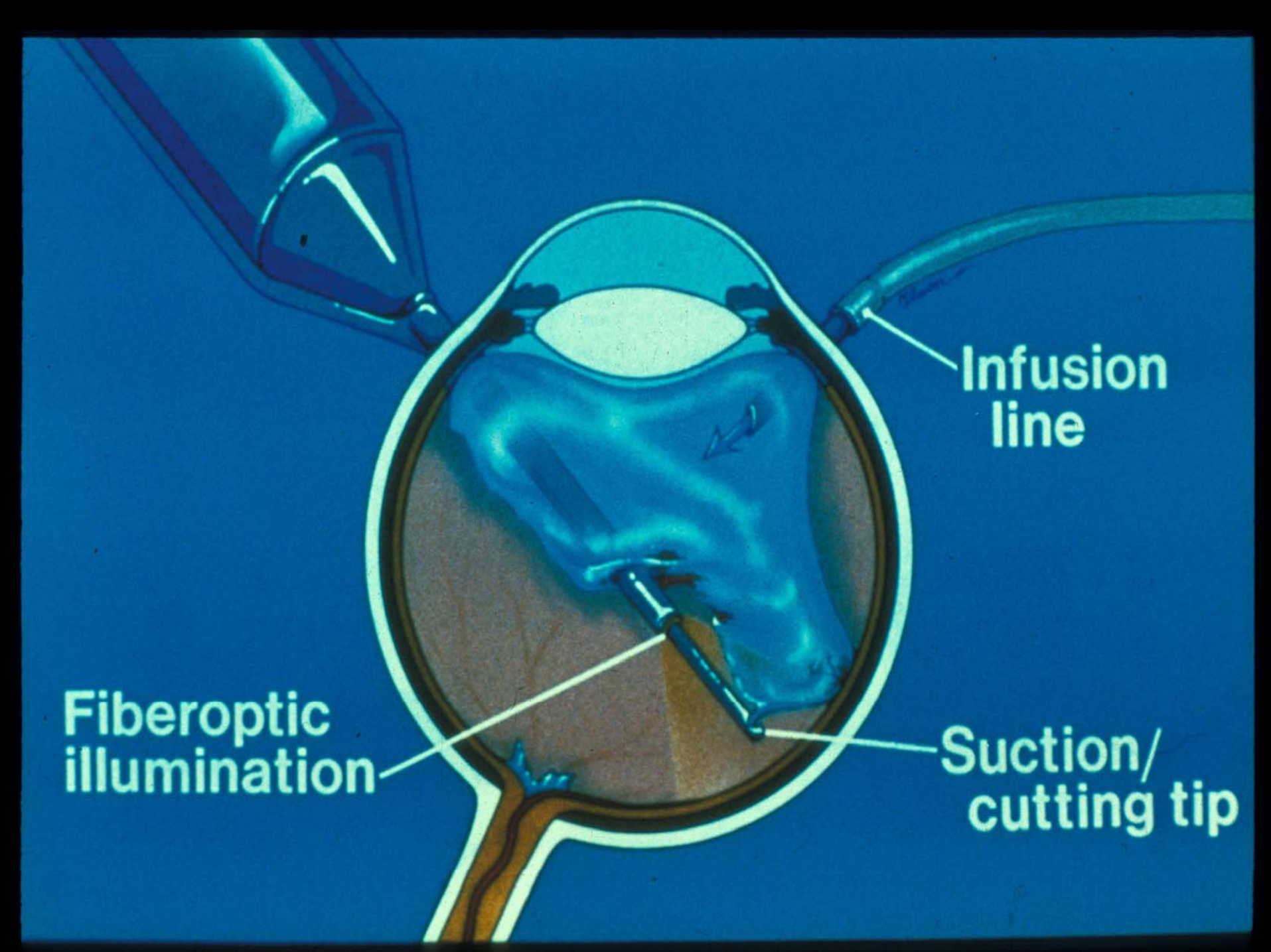

Danis P, et al. *IOVS* 1998; 39:171-179

# LY 333531 Ruboxistaurin

- Investigational compound in Phase III trials being developed as a pharmaceutical treatment for DR/DME
- Selective inhibitor of PKC-ß designed to measure reduction in progression of PPDR to PDR
- Being studied to treat underlying *cause* of DR/DME (hyperglycaemia-induced microvascular dysfunction) rather than treating symptoms

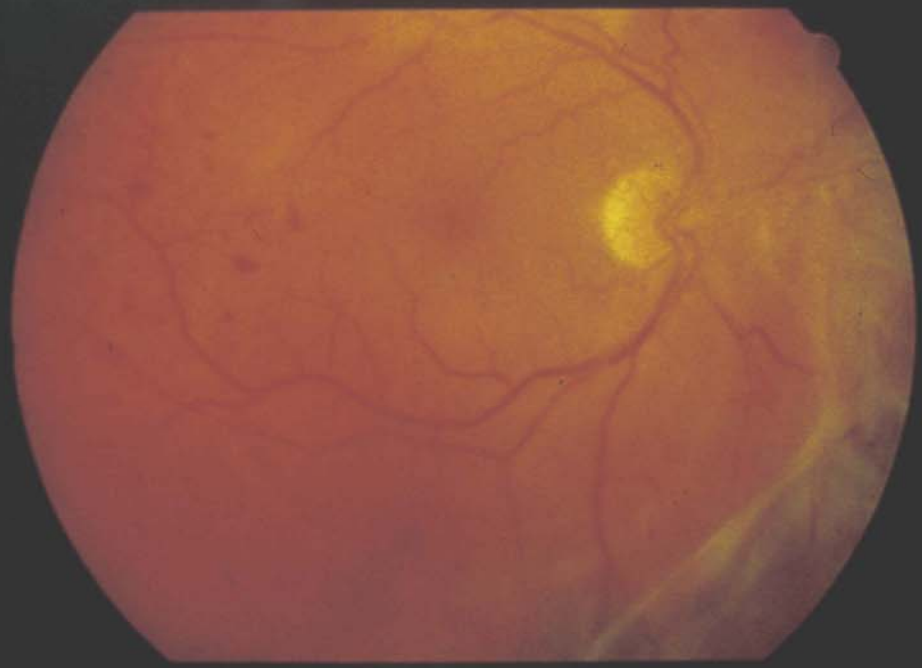
The natural history of diabetic retinopathy is well known,

*BUT* at present the only treatment available for sight-threatening retinopathy is with the laser, an invasive form of treatment


Infusion line
Fiberoptic illumination
Suction/ cutting tip

# Vitrectomy

Before



After

# SKIN CONDITIONS FOUND IN DIABETES

Disorders of the skin that are usually associated with diabetes:

- Necrobiosis lipoidica diabeticorum
- Diabetic dermopathy (shin spots, brown spots)
- Lipodystrophy
  - Hypertrophy
  - Atrophy
- Insulin allergy
- Skin reactions to oral hypoglycemic agents

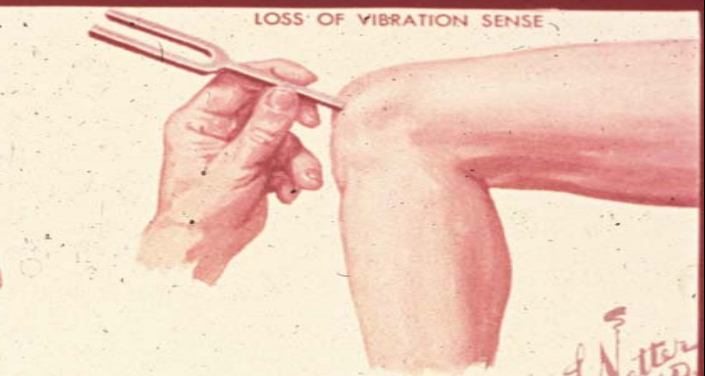
Disorders of the skin and other diseases that are frequently associated with diabetes:

- Skin infections
  - Bacterial infections
  - Moniliasis
  - Dermatophytosis
- Xanthomas
  - Xanthelasma
  - Xanthoma diabeticorum
- Arteriosclerosis obliterans
- Neuropathy
- Endocrine-metabolic
  - Acromegaly
  - Cushing's syndrome
  - Hemochromatosis
  - Xanthrochromia (carotenemia)

# DIABETES & DEPRESSION

- The incidence of moderate depression in diabetes patients approaches 40 % of patients.
- The stress of living with diabetes and a chronic condition accounts for some of the increased incidence.
- Many diabetes patients are not evaluated nor treated for depression.

WRIST DROP



ANKLE DROP

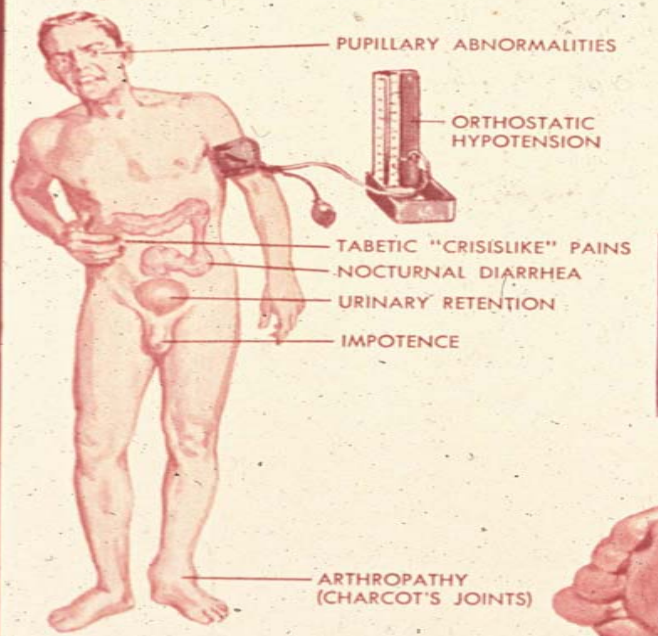
LOSS OF VIBRATION SENSE

F. Netter M.D.

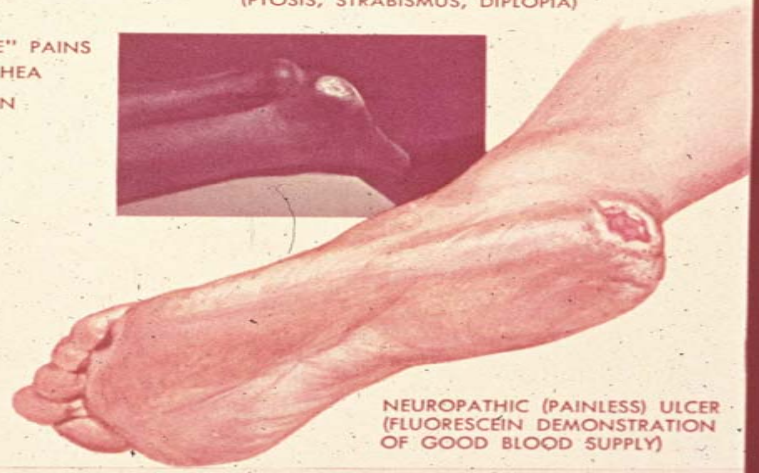
©CIBA

PARESTHESIA, HYPERALGESIA OR HYPESTHESIA

EXTRA—OCULAR MUSCLE PARALYSIS
(PTOSIS, STRABISMUS, DIPLOPIA)




AUTONOMIC DYSFUNCTIONS

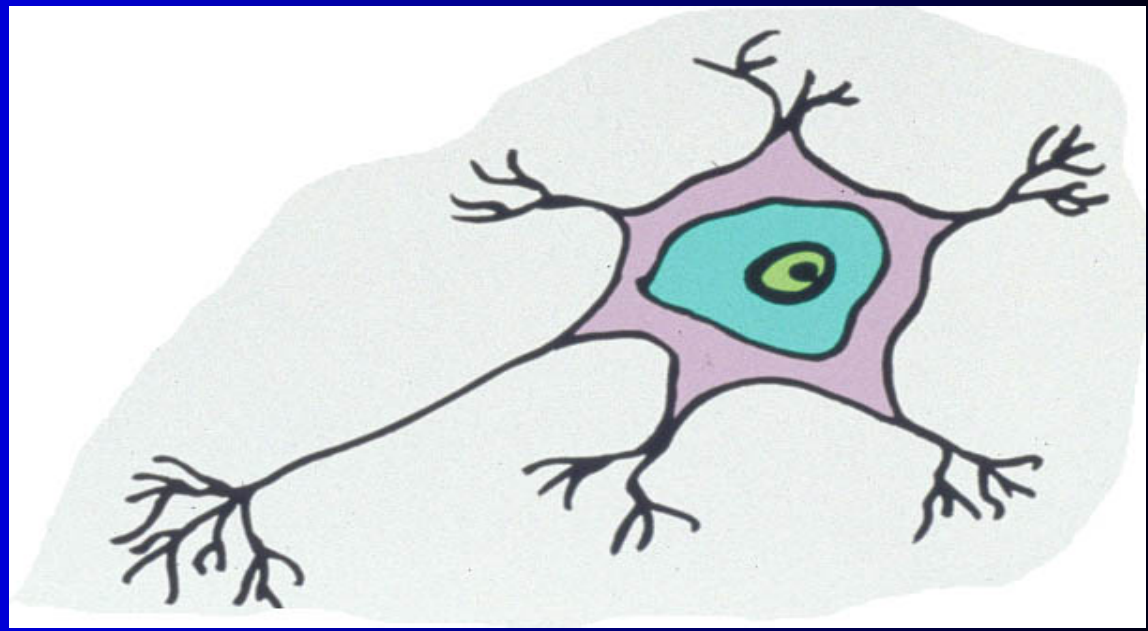


NEUROPATHIC (PAINLESS) ULCER
(FLUORESCEIN DEMONSTRATION
OF GOOD BLOOD SUPPLY)

1333 DIABETIC NEUROPATHY

# Diabetes Neuropathies

- Focal neuropathy
- Distal symmetrical polyneuropathy
- Autonomic neuropathy



# Visceral (Autonomic) Neuropathies

- Impaired CV reflexes
- Gastroparesis
- Diarrhea or constipation
- Neurogenic bladder
- Sexual dysfunction
- Neurotrophic arthropathy
- Neurotrophic ulcer

# Chronic Complications: Autonomic Neuropathies

- Orthrostatic hypotension
- Reduced hypoglycemic awareness
- Bladder dysfunction
- Gastroparesis / Constipation
- Diarrhea
- Fecal incontinence
- Sexual dysfunction

# Foot Problems: Warning Signs and Systems

- Loss of peripheral pulses
- Loss of distal foot and toe sensation
  - Semmes / Weinstein 10 gram monofilament testing

# Diabetic Gangrene

Diabetics are prone to develop gangrene, especially of the toes and feet, as result circulatory embarvassment incident to atherosclerotic vascular disease. A minor injury or local dermatitis may be the immediate cause. Prompt and vigorous treatment of the diabetics as well as the local lesions is indicated.

# Neuropathy

- Approximately 80% of lower extremity amputations (LEA) have a preliminary finding of PERIPHERAL NEUROPATHY
  - $27,000+ for LEA
  - $21,000+ for rehabilitation
- 50% of LEA's could have been prevented with proper foot care
- It is estimated that 15%–25% of diabetes patients will have a foot ulcer at some time over the course of their disease

# Neuropathy

- Peripheral neuropathy can precipitate foot ulcers
- Vascular Disease inhibits healing
- Hyperglycemia inhibits healing

# Neuropathy

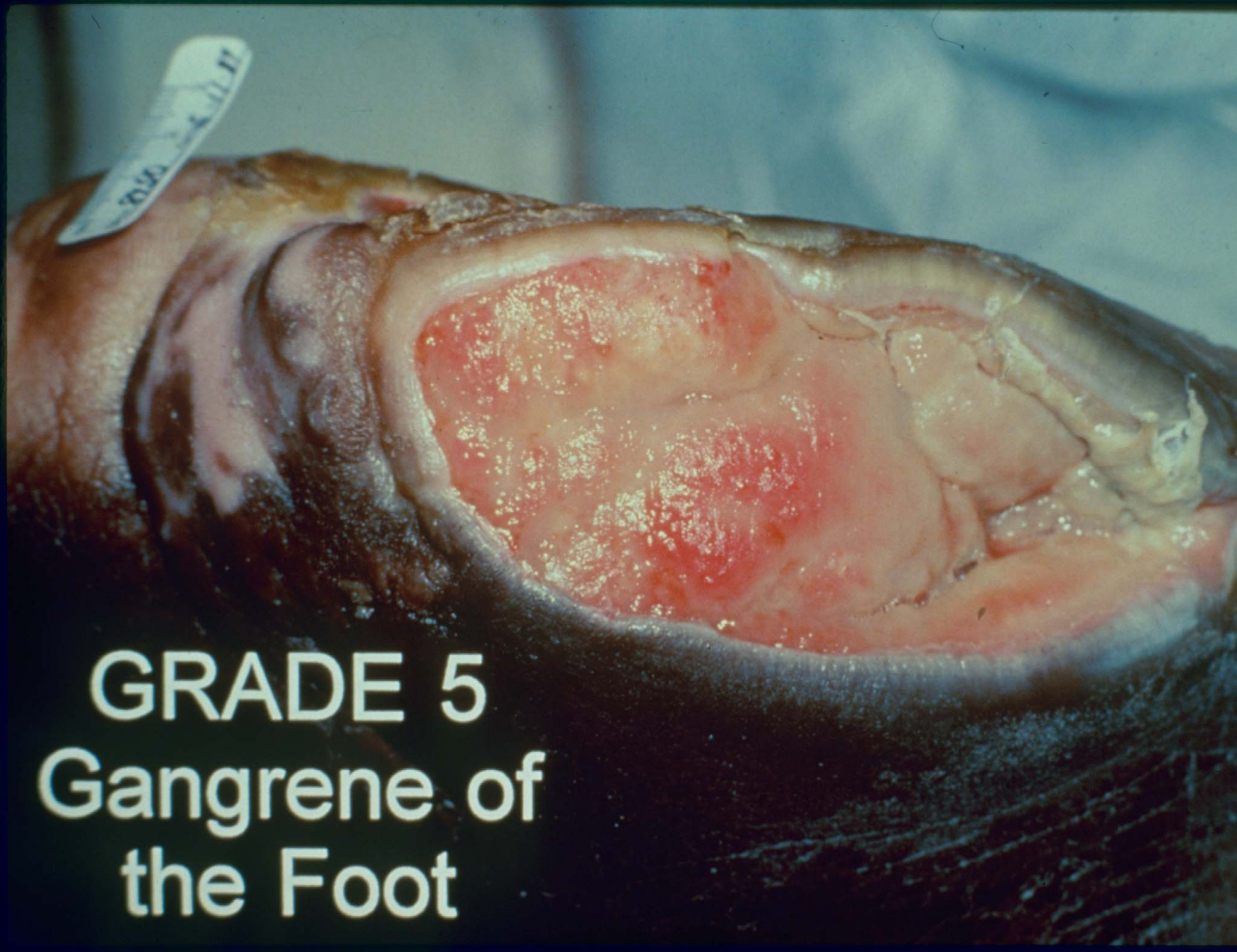
- 4 mechanical ways to damage feet
  - Direct Injury
  - Ischemia
  - Repetitive Stress
  - Infection
- Avoid Iodine, hydrogen peroxide, astringents
- Control blood glucose levels
- Smoking cessation


GRADE 1
Superficial Ulcer

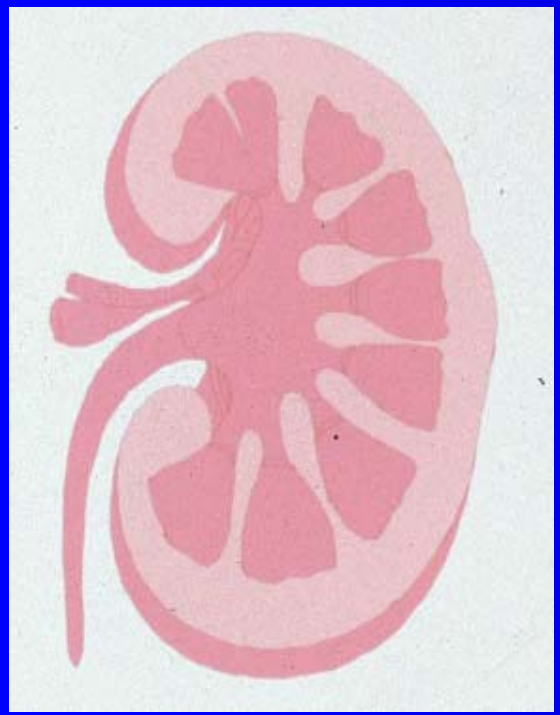

GRADE 2
Deep Ulcer


Appearance


GRADE 4
Gangrene of the
Toes or Forefoot


GRADE 5
Gangrene of
the Foot

# Renal Complications of Diabetes:Nephropathy



- Assessment of serum creatinine and urinary protein
- Intensify glycemic control
- Normalize blood pressure => 130/80 mm Hg
  - Caution with calcium channel blockers, beta blockers
- Use of ACE inhibitors/ARB's
  - Role of angiotensin II
  - Reduced progression to ESRD
- Dietary counseling: low protein diet

# Medications Used to Treat Diabetes Complications

- Tricyclic antidepressants, SSRI's (Cymbalta)
- Aspirin, NSAIDS, Anti Convulsants (Lyrica)
- Vitamin C, Vitamin E, MgCl, glucose tabs
- Reglan, Erythromycin, Antacids, PPI's, Capsaicin, Histamine 2 blockers
- ACE inhibitors, ARB's, diuretics, Trental, Plavix
- Ca channel blockers, tadalafil or sildenafil
- Lipid lowering meds (Zetia, Crestor, Lipitor)
- Hypoglycemic meds (oral agents and insulin)

# Meds to Treat/Prevent CV Disease in Diabetes Patients

- Aspirin
- ACE Inhibitors or ARBS or both
- Statins plus Coenzyme CQ-10
- Ezetimibe and/or Fibrates
- Anti-Oxidants and other micro-nutrients, especially Magnesium, folic acid + B vitamins
- Normalize blood glucose levels with a good treatment regimen

# Future **possible** Medications to Treat Microvascular Diabetes Complications

- **Ruboxistaurin (Arxxant)** is a PKC-Beta inhibitor. June 2005, Dr. Tuttle reported at ADA that it stopped the progression of kidney damage and reduced microalbuminuria by 25 %.
- **Benfotiamine** is a derivative of thiamine that blocks oxidative stress by activating transketolase**.**
- **PARP (Poly-ADP-ribose Polymerase) inhibitors** are being developed that block the 4 major pathways leading to oxidative stress and vessel damage.
- **Superoxide desmutase** will also block the oxidative stress pathways & hopefully will block complications.
- **Aldose Reductase Inhibitors: epalrestat** 300 mg/day improved retinopathy.
- **Alpha Lipoic Acid:** shows some promise with 2 large studies in progress.
- **Pimagedine:** inhibits AGE's and showed positive effects in treating nephropathy.