

COMPLICATIONS OF DIABETES



Chronic hyperglycemia (persistently high blood glucose) leads to both short-term and long-term complications that can affect nearly every organ system.

SHORT-TERM COMPLICATIONS

Develop over hours to days or weeks

1. HYPERGLYCEMIC SYMPTOMS

- Excessive urination (polyuria)
- Fatigue
- Unexplained weight loss
- Increased thirst (polydipsia)
- Blurred vision



2. ACUTE METABOLIC COMPLICATIONS

A. Diabetic Ketoacidosis (DKA)

- Occurs in ketosis-prone patients
- BG typically > 200–300 mg/dL
- Symptoms: nausea, vomiting, abdominal pain, rapid breathing, confusion
- Potentially life-threatening
- Requires hospitalization, IV fluids and electrolytes, insulin therapy



B. Hyperosmolar Hyperglycemic State (HHS)

- Occurs in non-ketosis-prone patients
- Severe hyperglycemia (often > 600 mg/dL)
- Symptoms: profound dehydration, altered mental status, weakness
- Potentially life-threatening
- Requires hospitalization, IV fluids and electrolyte replacement

3. INFECTIONS (SHORT-TERM RISK)

- Increased risk of soft-tissue infections (skin, abscesses, wounds)
- Increased risk of urinary tract infections (UTIs)
- Poor wound healing

LONG-TERM COMPLICATIONS

Develop over months to years due to vascular and tissue damage

MICROVASCULAR COMPLICATIONS (Affect small blood vessels)



1. DIABETIC NEPHROPATHY

- Damage to kidney filtering units
- Protein in urine (albuminuria)
- Progressive decline in kidney function
- May lead to chronic kidney disease (CKD) and end-stage renal disease (ESRD)



2. DIABETIC RETINOPATHY

- Damage to blood vessels in the retina
- Symptoms: blurred vision, floaters, poor night vision
- Can lead to cataracts, glaucoma, and retinal detachment
- Potentially leads to blindness



3. DIABETIC NEUROPATHY

- Damage to peripheral nerves
- Symptoms: numbness, tingling, burning pain, weakness
- Commonly affects feet and legs
- Can also affect autonomic nerves (GI, bladder, heart rate, etc.)

MACROVASCULAR COMPLICATIONS (Affect large blood vessels)



1. ASCVD – CARDIOVASCULAR DISEASE

- Accelerated atherosclerosis
- Increased risk of:
 - Coronary artery disease (heart attack)
 - Stroke
 - Peripheral artery disease (poor blood flow to legs)
- Leading cause of morbidity and mortality in diabetes



2. PERIPHERAL ARTERY DISEASE (PAD)

- Reduced blood flow to limbs
- Symptoms: leg pain while walking (claudication), cold feet, slow healing wounds
- Increases risk of ulcers and amputations



3. CEREBROVASCULAR DISEASE

- Increased risk of stroke (ischemic or hemorrhagic)
- Can lead to long-term disability or death

ADDITIONAL LONG-TERM COMPLICATIONS



1. DIABETIC FOOT COMPLICATIONS

- Combination of neuropathy, poor circulation, and immune dysfunction
- Risk of foot ulcers, infections, gangrene
- Major cause of toe, foot, and leg amputations



2. IMMUNE DYSFUNCTION

- Impaired immune response
- Greater susceptibility to infections
- Delayed healing



3. SEXUAL DYSFUNCTION

- Males: Increased risk of erectile dysfunction
- Females: Decreased libido, vaginal dryness, arousal difficulties



4. GASTROINTESTINAL COMPLICATIONS

- Gastroparesis
- Diabetic diarrhea
- Constipation



5. GENITOURINARY COMPLICATIONS

- Bladder dysfunction
- Recurrent UTIs
- Incontinence



KEY TAKEAWAY

Diabetes can affect nearly every organ system. Good glycemic control, regular monitoring, healthy lifestyle choices, and appropriate medical management are essential to prevent or delay complications and to improve quality of life and longevity.

DIABETIC KETOACIDOSIS (DKA)

Management Flow Chart (Step-by-Step)

1 RECOGNIZE DKA (Medical Emergency)



- Precipitating factors: missed insulin, infection, illness, stress ($\uparrow$ cortisol, catecholamines, glucagon, GH)
- May be alert, drowsy, stuporous, or comatose
- Look for infection (common cause)

DIAGNOSTIC HALLMARKS

- Hyperglycemia: BG > 250 mg/dL
- Anion gap metabolic acidosis: pH < 7.30 , $\text{HCO}_3^- < 18$ mEq/L, Anion gap $> 10-12$
- Large ketonemia or ketonuria (β -hydroxybutyrate elevated)



KEY POINTS

- DKA is a true EMERGENCY.
- Triad: Hyperglycemia + Anion gap acidosis + Ketosis.
- Treat with: Fluids $\rightarrow$ Potassium $\rightarrow$ Insulin $\rightarrow$ Dextrose (when BG < 250)
- Do not stop insulin until ketosis and acidosis resolve.
- Hourly glucose & frequent electrolyte monitoring are vital.

2 INITIAL ASSESSMENT & MONITORING



- Check vitals, mental status, weight
- Labs: BG (hourly), electrolytes (Na^+ , K^+ , Cl^- , HCO_3^-), BUN/Cr, anion gap, ketones, pH
- Monitor: urine output, blood pressure, ECG (if K^+ abnormal)

KEY DEFICITS



- Fluid deficit: several liters
- Sodium deficit
- Potassium deficit
- Total body K^+ is LOW (even if serum K^+ is normal or high)

3 FLUID RESUSCITATION



- Start 0.9% Normal Saline (NS) 15–20 mL/kg/hr (about 1–1.5 L in first hour)
- Continue NS based on hydration status
- When BG < 250 mg/dL, switch to 0.45% ($\frac{1}{2}$ NS) to replace free water

GOAL



- Restore intravascular volume
- Improve tissue perfusion
- Help kidney clear glucose & ketones

4 POTASSIUM REPLACEMENT (Essential)



- Check K^+ before starting insulin

$\text{K}^+ < 3.3$ mEq/L	Hold insulin, give K^+ 20–30 mEq/hr
$3.3 - 5.2$ mEq/L	Give K^+ 20–30 mEq/L in IV fluids
> 5.2 mEq/L	Do not give K^+ initially, monitor closely

- Check K^+ every 2–4 hours

GOAL

- Keep serum K^+ between 4.0 – 5.0 mEq/L

5 INSULIN THERAPY



- Start Regular Insulin (IV infusion): 0.1 units/kg/hr (fixed dose)
- Do NOT titrate based on BG level
- When BG < 250 mg/dL $\rightarrow$ add Dextrose (D5 or D10) to IV fluids and continue same insulin rate
- Continue insulin until:
 - Anion gap closes AND
 - Urine ketones are negative

ALTERNATIVES (if no hypoperfusion)

- Regular insulin IM or Insulin lispro/aspart SC every 1–2 hours

6 TRANSITION TO SUBCUTANEOUS INSULIN



- Give long-acting insulin (e.g., Glargine, Detemir) 1–3 hours BEFORE stopping IV insulin
- Continue IV insulin for 1–2 hours after long-acting insulin given

THEN

- Start usual meal-time insulin regimen and stop IV insulin

7 ADDITIONAL CONSIDERATIONS



- Bicarbonate: NOT recommended unless pH < 6.9 (may be harmful, esp. in children)
- Phosphorus: initially high $\rightarrow$ drops low; replacement not routinely recommended
- Treat the underlying cause (e.g., infection)
- Large volumes of NS may cause hyperchloremic metabolic acidosis $\rightarrow$ does not need specific treatment
- Improvement = $\uparrow$ pH or HCO_3^- , not just $\downarrow$ glucose

8 MONITORING (Essential)



- Glucose: every hour
- Electrolytes (especially K^+): every 2–4 hours
- Vitals, urine output, mental status: frequently
- Maintain a FLOW SHEET to track:
 - Fluids in/out
 - Insulin given
 - Lab values
 - Urine ketones

END POINTS (DKA RESOLVED)



- BG < 200 mg/dL
- $\text{HCO}_3^- \geq 18$ mEq/L
- pH > 7.30
- Anion gap $\leq 10-12$
- Negative ketones in urine



SUMMARY

Early recognition, aggressive fluid resuscitation, correct electrolyte replacement, and continuous insulin therapy are the cornerstones of DKA management.

Close monitoring and treating the underlying cause ensure recovery and prevent complications.

LAB TRENDS IN DKA

Glucose

$\uparrow$ High $\rightarrow$ Decreases

Bicarbonate (HCO_3^-)

$\downarrow$ Low $\rightarrow$ Increases

Anion Gap

$\downarrow$ High $\rightarrow$ Normalizes

Potassium (Serum)

$\downarrow$ May be normal/high $\rightarrow$ Decreases

Phosphorus

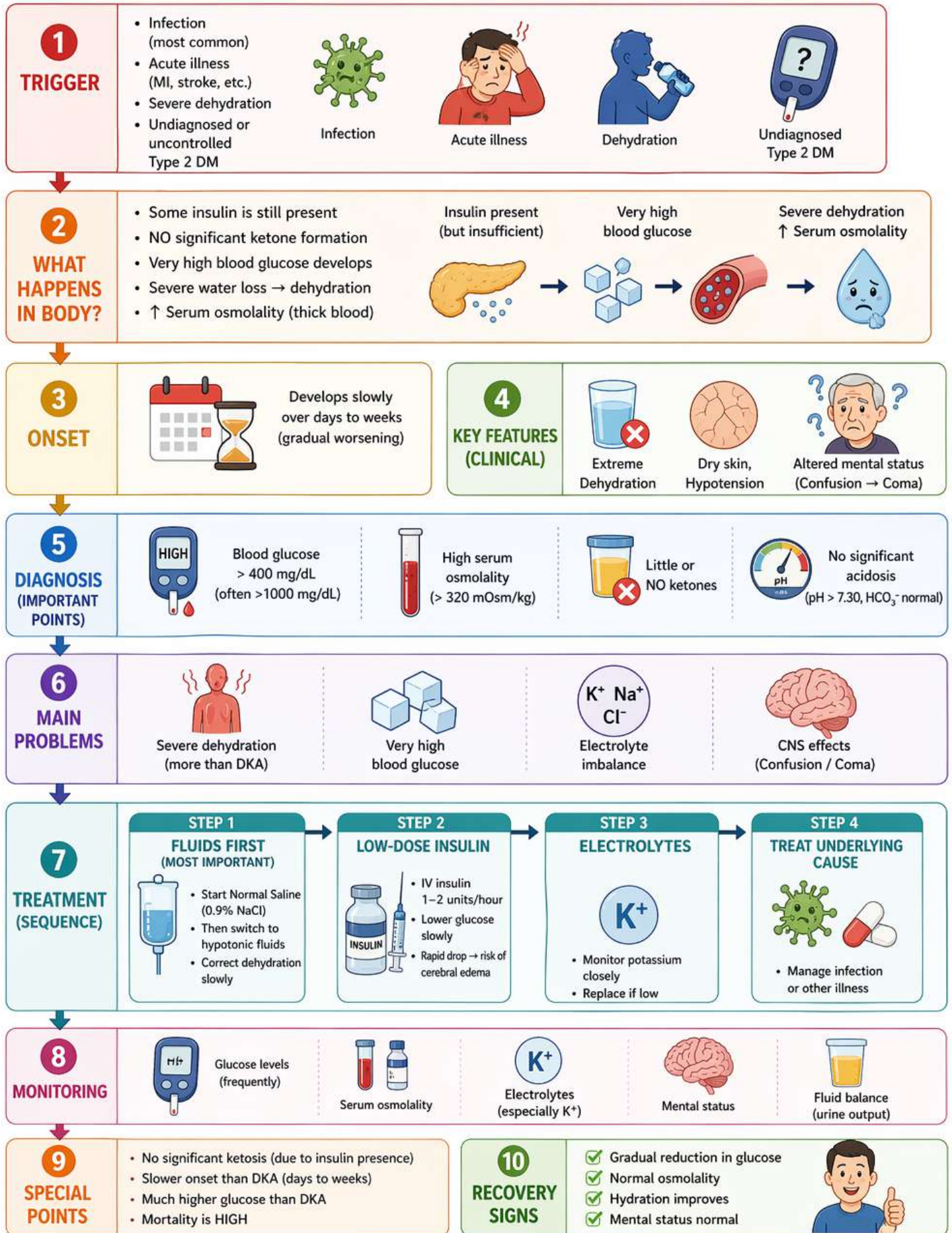
$\downarrow$ High $\rightarrow$ Low

pH

$\uparrow$ Low $\rightarrow$ Normalizes

HYPEROSMOLAR HYPERGLYCEMIC STATE (HHS)

A LIFE-THREATENING COMPLICATION OF DIABETES



KEY DIFFERENCE FROM DKA

 **HHS = VERY HIGH SUGAR + VERY DRY + SLOW ONSET + NO KETONES**

HHS

- Very high glucose (>400–1000 mg/dL)
- High osmolality
- Little or no ketones
- No significant acidosis
- Slow onset (days–weeks)

VS

DKA

- Moderate glucose (usually < 400–600 mg/dL)
- Normal or ↑ osmolality
- High ketones
- Acidosis present
- Rapid onset (hours–1 day)

 **DKA = HIGH SUGAR + KETONES + ACIDOSIS + RAPID ONSET**

MACROVASCULAR COMPLICATIONS OF DIABETES

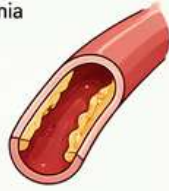
Leading cause of death in people with diabetes

1. DIABETES MELLITUS



2. PATHOPHYSIOLOGY

Chronic hyperglycemia
→ Endothelial injury
→ Atherosclerosis
(large blood vessel damage)



3. MAJOR MACROVASCULAR COMPLICATIONS



Coronary Heart Disease (CHD)
→ Myocardial infarction



Cerebrovascular Disease
→ Ischemic stroke



Peripheral Arterial Disease (PAD)
→ Claudication
→ Foot ulcers
→ Amputation

4. CARDIOVASCULAR RISK FACTORS (WORSEN OUTCOMES)



Dyslipidemia



Hypertension



Smoking



Obesity / Overweight



Sedentary lifestyle

5. MANAGEMENT STRATEGIES

A. LIFESTYLE MODIFICATION



Healthy diet (DASH diet)



Physical activity (≥150 min/week)



Weight loss



Smoking cessation

B. ANTIPLATELET THERAPY



If ASCVD present

- Low-dose aspirin (75–162 mg daily)



- If aspirin allergic → Clopidogrel

C. GLUCOSE-LOWERING DRUGS WITH CV BENEFIT



Consider in patients with ASCVD

- GLP-1 receptor agonists (e.g., liraglutide)
- SGLT2 inhibitors (e.g., empagliflozin, dapagliflozin)

- ✓ Reduce cardiovascular death
- ✓ Reduce heart failure hospitalization

D. BLOOD PRESSURE CONTROL



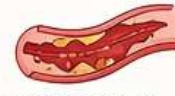
- If BP > 140/90 mmHg → Start medications
- If BP > 160/100 mmHg → Use 2 medications

First-line:
ACE inhibitors / ARBs

↓

Add-on:
Thiazide diuretics / Calcium channel blockers (CCBs)

E. LIPID MANAGEMENT



- Statin therapy for ALL patients with diabetes

- ASCVD present → High-intensity statin
- Age > 40 years → Moderate-intensity statin

- If Triglycerides ≥ 500 mg/dL (additional therapy)
- Fibrate (e.g., fenofibrate)
 - Omega-3 fatty acids
 - Niacin

F. POST-MI MANAGEMENT



β-blocker therapy recommended

- ✓ Reduces recurrent CHD events
- ✓ Benefit greater in patients with diabetes

Do not avoid β-blockers if indicated

(Monitor for masked hypoglycemia symptoms: watch for sweating, neuroglycopenic symptoms)

G. PERIPHERAL ARTERIAL DISEASE (PAD) MANAGEMENT



Risk factors:
Diabetes,
Smoking,
Atherosclerosis



Symptoms:
Claudication
→ Pain in legs
Non-healing foot ulcers



Management:

- Smoking cessation
- Statin therapy
- Good glycemic control
- Antiplatelet therapy
- Cilostazol (in select patients)



Revascularization surgery
(Consider in suitable patients)



Foot care:
Early detection, debridement, appropriate footwear



Advanced care:
Skin grafts, topical wound healing, hyperbaric treatments

H. FOOT CARE & SCREENING (PREVENTION OF AMPUTATION)



Examine feet at each face-to-face encounter



Yearly 10-g Semmes-Weinstein monofilament test (to assess loss of protective sensation)



Identify high-risk patients



Provide routine podiatric care and education



Closer follow-up and regular monitoring

KEY TAKEAWAY



Control risk factors aggressively to reduce macrovascular events and improve survival in patients with diabetes.

Good glycemic control + Risk factor management = Reduced cardiovascular events & improved quality of life



PREGNANT WOMEN & DIABETES

PRECONCEPTION CARE



- Discuss family planning early
- Achieve good glycemic control BEFORE pregnancy
- Organogenesis completed in first 8 weeks
- Poor glucose control in 1st trimester → major congenital malformations (leading cause of infant mortality & serious morbidity)
- Review all medications for safety
- Stop teratogenic drugs (e.g., ACE inhibitors, statins) and use safe alternatives if needed



IF PREGNANT (Type 1 or Type 2 DM)

- Intensify glucose monitoring & management
- Normoglycemia reduces risk of complications
- Frequent follow-up with diabetes & obstetric team
- Monitor for hypertension, proteinuria, and other complications
- Plan delivery & postpartum care



GESTATIONAL DIABETES MELLITUS (GDM)

1. SCREENING

All women should be screened for GDM between 24–28 weeks of pregnancy



2. ADVERSE OUTCOMES



Birth defects



Miscarriage



Cesarean delivery



Maternal preeclampsia/eclampsia



Preterm delivery



Neonatal hypoglycemia



Shoulder dystocia / birth injury



Hyperbilirubinemia

3. MANAGEMENT PRINCIPLES

- Medical nutritional therapy is paramount
- Minimize wide fluctuations in BG
- Intensive education & self-monitoring
- Avoid ketosis



4. GLYCEMIC GOALS

For GDM

- Fasting glucose < 95 mg/dL
- 1-hour postprandial < 140 mg/dL OR
- 2-hour postprandial < 120 mg/dL

For Pregestational DM (Type 1 or Type 2)

- Premeal, bedtime & overnight SMBG < 95 mg/dL
- Peak postprandial < 140 mg/dL
- A1C ideally 6% – 6.5% (use SMBG to guide therapy)

5. TREATMENT APPROACH

A. LIFESTYLE & EDUCATION



Medical nutritional therapy



Physical activity



Intensive education

B. MEDICATION THERAPY

If lifestyle goals not met → Medication needed



- First-line treatment
- NPH insulin is recommended basal insulin
- Insulin detemir appears to be safe
- Insulin pump therapy (CSII) can be used in motivated patients

Alternatives in GDM (Type 2 DM or GDM)



Metformin



Glyburide

- Both appear effective in small studies
- Metformin crosses placenta
- More safety data needed
- If insulin not possible/accepted → may be considered

C. INSULIN REGIMEN



- May need intensive, multidosed regimens
- Carbohydrate counting & SMBG-guided adjustments
- Goals more stringent during pregnancy

D. SAFE MEDICATIONS

Generally considered safe:

- Insulin (all types)
- Metformin (caution)
- Glyburide (caution)

AVOID in pregnancy:

- ACE inhibitors
- ARBs
- Statins
- Certain other drugs (review all medications)



6. POSTPARTUM CARE

A. AFTER DELIVERY

Evaluate at ~ 6 weeks postpartum to ensure normoglycemia has returned



B. LONG-TERM RISK

Women with history of GDM have 30% – 50% lifetime risk of developing Type 2 DM



C. FOLLOW-UP



- Periodic screening for diabetes
- Healthy lifestyle (diet, exercise, weight control)
- Future pregnancy planning & counseling

D. BREASTFEEDING



- Encouraged
- Safe for both mother and baby
- May improve glucose metabolism

KEY TAKEAWAYS



Good glucose control BEFORE and during pregnancy is critical



Poor control in 1st trimester → birth defects & serious complications



Screen all women for GDM at 24–28 weeks



Meet glycemic goals with nutrition, monitoring & medication if needed



Postpartum follow-up is essential due to high future risk of Type 2 DM

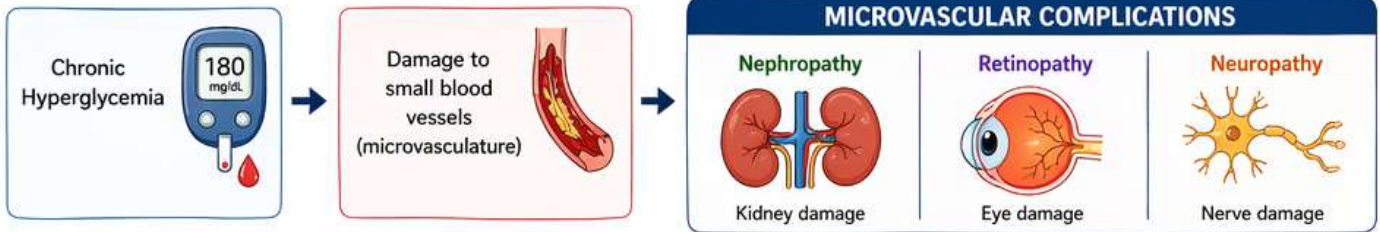


Healthy mother → Healthy baby → Healthy future

Team care, education & monitoring = Best outcomes

MICROVASCULAR COMPLICATIONS OF DIABETES

Closely related to glycemic control – Early detection and optimal management can prevent or slow progression



1. NEPHROPATHY (KIDNEY DISEASE)



Leading cause of end-stage renal disease (ESRD) in people with diabetes

A. SCREENING FOR ALBUMINURIA

- Type 2 DM: at diagnosis
- Type 1 DM: after puberty and after 5 years of disease duration

Methods

1. Random spot (first-morning void)
2. 24-hour timed collection
3. Timed collection (4–10 hr overnight)

Albuminuria Categories (Spot urine ACR)

Normal to mildly increased	< 30 mg/g (< 3.4 mg/mmol)
Moderately increased	30 – 299 mg/g (3.4 – 33.8 mg/mmol)
Severely increased	≥ 300 mg/g (≥ 33.9 mg/mmol)

- Confirm on ≥ 2 of 3 samples over 3–6 months
- Exclude conditions causing transient rise: exercise, UTI, hypertension, hyperglycemia, heart failure, fever

B. MANAGEMENT

- Tight glucose control
- Blood pressure control (goal < 140/90 mmHg; lower goal < 130/80 mmHg if tolerated)
- ACE inhibitors or ARBs – slow progression
- Do NOT combine ACEi + ARB (no added benefit, more adverse effects)
- Diuretics – second line (volume control)
- Often need ≥ 3 antihypertensive agents
- SGLT2 inhibitors (empagliflozin, canagliflozin, dapagliflozin) – reduce progression of CKD (eGFR 30–60 mL/min/1.73m² or UACR > 30 mg/g)



ACEi/ARB



Diuretic



SGLT2 inhibitor

2. RETINOPATHY (EYE DISEASE)



Caused by retinal ischemia and abnormal release of vascular growth factors

A. SCREENING



- Dilated eye exam for all patients with diabetes
- Type 1 DM: within 5 years of diagnosis
- Refer to ophthalmologist/optometrist trained in diabetic eye disease

B. KEY POINTS

- Early background retinopathy may reverse with good glycemic & BP control
- Advanced retinopathy may not fully regress
- Rapid reductions in BG may temporarily worsen retinopathy

C. TREATMENT

Laser Photocoagulation



- Recommended for macular edema and proliferative retinopathy

Anti-VEGF Therapy



- Intravitreal injections
- Bevacizumab (off-label)
- Ranibizumab
- Aflibercept

Also more common in diabetes:



Cataracts



Open-angle Glaucoma

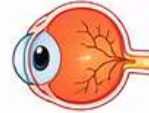
MICROVASCULAR COMPLICATIONS

Nephropathy



Kidney damage

Retinopathy



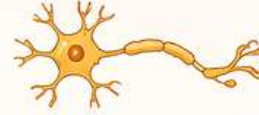
Eye damage

Neuropathy



Nerve damage

3. NEUROPATHY (NERVE DISEASE)



Affects nerves throughout the body

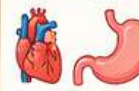
A. TYPES OF NEUROPATHY

1. Peripheral Neuropathy



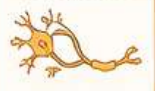
Distal symmetric numbness, pain, tingling (feet > hands)

2. Autonomic Neuropathy



Affects involuntary body functions (see below)

3. Focal Neuropathies



Sudden weakness or palsy in specific nerves

B. PERIPHERAL NEUROPATHY

- Primary treatment: Improve glycemic control
- For painful neuropathy (symptom relief only):



TCA (nortriptyline, desipramine)



Duloxetine



Gabapentin/Pregabalin



Venlafaxine



Topical Capsaicin / Tramadol

- No medication helps numbness
- High risk for foot ulcers → daily foot care essential

C. AUTONOMIC NEUROPATHY – MANIFESTATIONS & MANAGEMENT

Cardiovascular



- Resting tachycardia
- Orthostatic hypotension
- Silent MI risk

Tx: Stop antihypertensives, liberalize salt, fluids

- Fludocortisone
- Midodrine
- Sit/sleep upright if severe

Gastrointestinal



- Gastroparesis
- Constipation
- Diarrhea

Tx: Improve glycemia, stop motility-slowing drugs

- Metoclopramide or low-dose erythromycin
- Domperidone*
- Gastric pacemaker (if severe)
- Diarrhea: rule out other causes
- Doxycycline or Metronidazole (10–14 days)
- Octreotide if needed

Genitourinary



- Erectile dysfunction

Tx: PDE-5 inhibitors (sildenafil, etc.) (Use higher doses may be needed)

Sudomotor



- ↓ Sweating, dry skin
- Gustatory sweating
- Heat intolerance

Tx: Hydrating creams Antiperspirants or anticholinergic drugs if excessive sweating

*Not approved in U.S.; available in many countries (FDA compassionate use)

D. FOCAL NEUROPATHIES

- Cranial nerve III, IV, VI palsies, Bell's palsy → dramatic but usually self-limited (weeks-months)
- Diabetic amyotrophy → proximal thigh pain & weakness (debilitating)
- Carpal tunnel syndrome (median nerve), Tarsal tunnel syndrome (foot paresthesias) → more common in diabetes

KEY TAKEAWAYS



Good glycemic control is the foundation



Screen early for kidney damage (albuminuria)



Regular dilated eye exams preserve vision



Foot care & neuropathy screening prevent ulcers



Control BP, use ACEi/ARB, SGLT2 inhibitors & other appropriate therapies



Early detection + appropriate treatment = better outcomes



Microvascular complications are preventable and treatable – Act early, Act consistently!