MEDICAL EDUCATION RESOURCE

# Regulation of Blood Glucose, Insulin and Diabetes Mellitus

## ? REGULATION OF BLOOD GLUCOSE, GLUCOSE TESTING, GTT, IGT, IFG, INSULIN & DIABETES MELLITUS

Structured for fast reading + perfect for MBBS/PG students.

## ? REGULATION OF BLOOD GLUCOSE

### ? Normal Fasting Blood Glucose

- **70–110 mg/dL** (lab-to-lab variation exists).

### ? Major organs involved

- **Liver** (primary regulator)
- **Muscle**
- **Adipose tissue**
- **Pancreas (Islets of Langerhans)**
- **Brain** (uses glucose continuously)

### ? Hormonal Regulation

### ? 1. Insulin (?-cells)

**Lowers blood glucose**

How?

- ? Glucose uptake (muscle, adipose)
- ? Glycogenesis
- ? Lipogenesis
- ? Protein synthesis
- ? Gluconeogenesis
- ? Glycogenolysis
- ? Lipolysis

**? 2. Glucagon (?-cells)**

**Raises blood glucose**

- ? Glycogenolysis
- ? Gluconeogenesis
- ? Lipolysis

**? 3. Adrenaline**

- Rapid ? in glucose
- ? Glycogenolysis; ? insulin secretion

**? 4. Cortisol**

- ? Gluconeogenesis
- ? Protein breakdown
- Causes hyperglycemia

### ? 5. Growth Hormone

- Anti-insulin effect
- ? Lipolysis
- ? Insulin resistance

### ? 6. Thyroid Hormones

- Mild ? glucose absorption & utilization

---

## ? Sources of Blood Glucose

- Dietary carbohydrates
- Liver glycogen breakdown
- Gluconeogenesis (lactate, glycerol, amino acids)

---

## ? DETERMINATION OF BLOOD GLUCOSE

### ? Sample Handling

- Collected in **fluoride vial** ? inhibits glycolysis
- Plasma preferred over serum

### ? Laboratory Methods

1. **Glucose oxidase–peroxidase (GOD–POD)**
    - Most common; specific
2. **Hexokinase method**
    - Reference method
3. **Ortho-toluidine**
    - Older method; less specific
4. **Glucometer**
    - Uses **glucose oxidase** or **glucose dehydrogenase**

---

## ? GLUCOSE TOLERANCE TEST (GTT / OGTT)

### ? Indications

- Suspected diabetes
- Gestational diabetes
- Impaired glucose tolerance evaluation

### ? Preparation

- 3 days: normal carbohydrate diet
- Overnight fast: 10–16 hours
- No smoking/exercise during test

**? Procedure**

- Fasting blood glucose measured
- Administer **75 g anhydrous glucose** orally
- Measure plasma glucose at **2 hours**

---

## ? Interpretation (WHO Criteria)

**? Fasting Glucose**

- Normal: **<100 mg/dL**
- IFG: **100–125 mg/dL**
- Diabetes: **?126 mg/dL**

**? 2-hour Post Glucose**

- Normal: **<140 mg/dL**
- IGT: **140–199 mg/dL**
- Diabetes: **?200 mg/dL**

---

## ? IMPAIRED GLUCOSE TOLERANCE (IGT)

- Fasting: **<126 mg/dL**
- 2 hours post-glucose: **140–199 mg/dL**
- Indicates **pre-diabetes** ? high risk for progression.

## ? IMPAIRED FASTING GLYCEMIA (IFG)

- Fasting glucose: **100–125 mg/dL**
- 2-hour value: **<140 mg/dL**
- Represents early glucose dysregulation.

## ? INSULIN

### ? Secretion

- From **?-cells** as **proinsulin ? insulin + C-peptide**
- C-peptide helps measure endogenous insulin levels.

### ? Stimulated by

- Glucose (most potent)
- Amino acids
- Fatty acids

- Incretins (GLP-1, GIP)

**? Mechanism of action**

- Via **tyrosine kinase receptor**
- Activates:
  - **GLUT-4 translocation** in muscle + adipose
  - Glycogen synthesis
  - Lipogenesis
  - Protein synthesis

---

## ? DIABETES MELLITUS

---

### ? Diagnostic Criteria

Any one:

- Fasting glucose **?126 mg/dL**
- Random glucose **?200 mg/dL** + symptoms
- 2-hour glucose **?200 mg/dL**
- HbA1c **?6.5%**

---

## ? Types of Diabetes

### ? Type 1 DM

- Autoimmune ?-cell destruction
- Absolute insulin deficiency
- Seen in children
- Prone to ketoacidosis
- C-peptide low

### ? Type 2 DM

- Insulin resistance + ?-cell dysfunction
- Associated with obesity
- C-peptide normal/high early, low late
- More common in adults

### ? Gestational Diabetes Mellitus (GDM)

- Detected at **24–28 weeks**
- 75 g OGTT:
  - Fasting ?92
  - 1 hour ?180

- 2 hour ?153

---

## ? Complications of Diabetes

### ? Acute

- DKA
- HHS (Type 2)
- Hypoglycemia

### ? Chronic

- **Microvascular**: retinopathy, nephropathy, neuropathy
- **Macrovascular**: CAD, stroke, PVD
- Foot ulcers
- Infections

---

## ? Laboratory Markers in Diabetes

- **HbA1c** ? reflects 3-month glucose
- **Fasting glucose**
- **C-peptide** ? endogenous insulin

- **Urine ketones** ? DKA
- **Autoantibodies** (GAD, IA-2) in Type 1 DM

---

## ? Ultra-Short High-Yield Summary

- Insulin ? glucose; glucagon ? glucose.
- GOD–POD is the commonest glucose test.
- OGTT uses **75 g** glucose; 2-hour >200 = diabetes.
- IFG = fasting 100–125; IGT = 2-hour 140–199.
- Insulin acts via **tyrosine kinase / GLUT-4**.
- Type 1 = autoimmune; Type 2 = insulin resistance.
- HbA1c ?6.5% = diabetes.
- C-peptide = endogenous insulin marker.

## ? GESTATIONAL DIABETES MELLITUS (GDM)

### ? Definition

Any degree of glucose intolerance **first recognized during pregnancy** (usually 2nd or 3rd trimester).

---

### ? Why does GDM occur?

Pregnancy hormones cause **insulin resistance**:

- Human placental lactogen (hPL)
- Progesterone
- Cortisol
- TNF-?
- Growth hormone

Pancreas cannot compensate ? hyperglycemia.

---

### ? Risk Factors

- Obesity
- Family history of diabetes
- Previous GDM
- PCOS
- Macrosomic baby in past pregnancy
- Multiple pregnancy
- Age > 25 years

- Unexplained stillbirth

---

## ? Screening (24–28 weeks)

**75 g OGTT single-step test (DIPSI / WHO):**

Venous plasma glucose:

- **Fasting ? 92 mg/dL**
- **1 hour ? 180 mg/dL**
- **2 hour ? 153 mg/dL**

Any **one** abnormal value = **GDM**.

---

## ? Complications

### ? Maternal

- Type 2 DM later in life
- Pre-eclampsia
- Polyhydramnios
- Preterm labor

### ? Fetal

- Macrosomia

- Shoulder dystocia
- Neonatal hypoglycemia
- RDS
- Hyperbilirubinemia
- Stillbirth (uncontrolled GDM)

---

## ? Management

- Diet + exercise (first line)
- Medical nutrition therapy
- **Insulin** if needed
- Metformin (allowed in many guidelines)
- Continuous glucose monitoring in high-risk cases
- Frequent fetal monitoring

---

## ? Postpartum

- Re-test mother at **6–12 weeks postpartum** ? 75 g OGTT
- High risk of future Type 2 diabetes

---

## ? ALIMENTARY GLUCOSURIA

### ? Definition

Presence of glucose in urine after a **high-carbohydrate meal**, despite **normal blood glucose**.

---

### ? Cause

- Rapid intestinal absorption ? sudden transient rise in blood glucose
- Exceeds temporary **renal threshold** ? glucose spills into urine
- Often seen after heavy sweets/starch intake

---

### ? Key Points

- **Blood glucose is normal again** by the time test is done.
- No kidney disease.
- No diabetes.
- Common in:
  - Pregnancy
  - Large carbohydrate load
  - Individuals with **low renal threshold**

---

### ? Clinical Importance

- Benign condition
- Does **not** progress to diabetes
- Needs reassurance, not treatment

---

## ? RENAL GLUCOSURIA

### ? Definition

Glucosuria **despite normal blood glucose** because of **defective glucose reabsorption** in renal tubules.

---

### ? Types

#### ? 1. Familial Renal Glucosuria

- Mutation in **SGLT2** transporter (proximal tubule)
- Glucose reabsorption impairment
- Autosomal recessive
- Completely benign

#### ? 2. Secondary Causes

- Fanconi syndrome

- Pregnancy
- Heavy metal poisoning
- Certain drugs (e.g., SGLT2 inhibitors — intentionally cause glucosuria)

---

## ? Key Features

- Blood glucose = normal
- Persistent glucosuria
- No ketones
- No hyperglycemia
- Normal GTT
- No treatment usually required

---

## ? Differentiation from Alimentary Glucosuria

| FEATURE | ALIMENTARY | RENAL GLUCOSURIA |
|---|---|---|
| Cause | High CHO load | Tubular defect |
| Duration | Temporary | Persistent |
| Blood glucose | Normal | Normal |

| FEATURE | ALIMENTARY | RENAL GLUCOSURIA |
|---|---|---|
| GTT | Normal | Normal |
| Pathology | None | Proximal tubule SGLT2 defect |

## ? Ultra-Short Summary

- **GDM** ? insulin resistance of pregnancy; diagnosed by 75 g OGTT; risk of macrosomia & neonatal hypoglycemia.
- **Alimentary glucosuria** ? glucose in urine after heavy carb intake; benign; transient.
- **Renal glucosuria** ? due to tubular SGLT2 defect; persistent glucosuria with normal sugars; benign.

## ? REDUCING SUBSTANCES IN URINE

### ? What are reducing substances?

Compounds that reduce **cupric ($Cu^{2?}$) to cuprous ($Cu?$)** ions in Benedict's / Fehling's test.

### ? Common Reducing Substances

- **Glucose** (most common)
- **Fructose**
- **Galactose**
- **Lactose**

- **Pentoses**
- **Ascorbic acid**
- Certain **drugs** (salicylates, nalidixic acid)

**? Why important?**

- Positive Benedict's test ? Diabetes
- Must confirm **specific sugar** (glucose oxidase dipstick is specific for glucose)

**? Clinical Contexts**

- **Galactosemia** ? galactose in urine
- **Hereditary fructose intolerance** ? fructose in urine
- **Alimentary glucosuria** ? transient glucose
- **Renal glucosuria** ? glucose with normal blood sugar

---

## ? GLYCOSURIA

**? Definition**

Presence of **glucose in urine**.

**? Mechanism**

Occurs when:

1. **Blood glucose exceeds renal threshold**
   (~ 180 mg/dL in normal adults)

2. **Renal tubular reabsorption defect**
   (renal glucosuria)

---

## ? Types of Glycosuria

### ? 1. Diabetic Glycosuria

- Hyperglycemia exceeds renal threshold ? glucose appears in urine.

### ? 2. Renal Glycosuria

- Normal glucose but proximal tubule cannot reabsorb it
- Seen in:
  - Familial renal glucosuria (SGLT2 defect)
  - Fanconi syndrome
  - Pregnancy (lowered renal threshold)

### ? 3. Alimentary Glycosuria

- After heavy carbohydrate meal
- Temporary and benign

### ? 4. Endocrine Glycosuria

Hormones increasing glucose:

- Hyperthyroidism

- Cushing syndrome
- Acromegaly
- Pheochromocytoma

## ? DIABETES MELLITUS (DM)

### ? Definition

Metabolic disorder characterized by:

- **Hyperglycemia**
- Disturbed metabolism of **carbohydrates, fats, proteins**
- Due to **insulin deficiency/resistance**

## ? Diagnostic Criteria (any one)

- Fasting plasma glucose **?126 mg/dL**
- Random plasma glucose **?200 mg/dL** + symptoms
- 2-hour OGTT value **?200 mg/dL**
- HbA1c **?6.5%**

## ? Types

### ? Type 1 DM

- Autoimmune destruction of ?-cells
- Absolute insulin deficiency
- Younger age, thin body
- Prone to DKA

**? Type 2 DM**

- Insulin resistance + ?-cell dysfunction
- Associated with obesity
- Most common
- May develop HHS

**? Gestational DM**

- Onset during pregnancy
- Diagnosed using 75 g OGTT

**? Secondary DM**

- Pancreatitis, Cushing, acromegaly, steroid use, hemochromatosis

## ? CLINICAL PRESENTATION OF DIABETES

### ? 1. Classical Symptoms (“3 Ps”)

- **Polyuria**
- **Polydipsia**
- **Polyphagia**
- Often with **weight loss**

### ? 2. Acute Presentation

- Blurred vision
- Fatigue
- Recurrent infections (UTI, candidiasis)
- Slow wound healing
- Ketonuria (Type 1)
- DKA or HHS in severe cases

### ? 3. Chronic Complications

#### ? Microvascular

- Retinopathy
- Nephropathy
- Neuropathy (peripheral, autonomic)

#### ? Macrovascular

- Coronary artery disease
- Stroke
- Peripheral vascular disease

**? 4. Other Features**

- Acanthosis nigricans (insulin resistance)
- Skin infections (furuncles, candidiasis)
- Erectile dysfunction
- Neuropathic foot pain

---

## ? Ultra-High Yield Summary

- **Reducing substances ? glucose** ? Benedict's detects *all* reducing sugars.
- Dipstick detects **only glucose** (glucose oxidase).
- Glycosuria occurs when **blood glucose crosses renal threshold** or **tubular defect exists**.
- Diabetes diagnosed by FPG ?126, 2 h OGTT ?200, or HbA1c ?6.5%.
- Classical diabetes symptoms = **polyuria, polydipsia, polyphagia, weight loss**.
- Type 1 ? autoimmune ? absolute insulin deficiency ? DKA prone.
- Type 2 ? insulin resistance ? obesity ? HHS risk.

## ? DIABETIC KETOACIDOSIS (DKA)

*(Acute emergency of Type 1 DM)*

### ? Pathophysiology

- Absolute **insulin deficiency**
- ? Glucagon ? ? Lipolysis ? ? Free fatty acids
- FFAs enter liver ? **excess ketone bodies**:
  - Acetoacetate
  - ?-Hydroxybutyrate
  - Acetone
- Results in **metabolic acidosis** (high anion gap)

### ? Triggers

- Infection (most common)
- Missed insulin doses
- Myocardial infarction
- Stroke
- Trauma

- Surgery

**? Clinical Features**

- Polyuria, polydipsia, dehydration
- Kussmaul breathing (deep, rapid)
- Fruity (acetone) breath
- Abdominal pain, vomiting
- Altered consciousness

**? Laboratory Findings**

- Blood glucose: **250–600 mg/dL**
- pH **<7.3**
- HCO?? **<18 mEq/L**
- Positive ketones
- High anion gap metabolic acidosis
- Potassium: initially high, body stores depleted

**? Management**

- IV fluids (NS)
- IV insulin infusion

- Potassium replacement
- Treat trigger (infection, etc.)

## ? HYPEROSMOLAR NONKETOTIC COMA (HHS / HONC)

*(Acute emergency of Type 2 DM)*

### ? Pathophysiology

- Severe hyperglycemia ? profound dehydration
- **Enough insulin present** to prevent ketosis
- Very high osmolality ? CNS depression

### ? Clinical Picture

- Elderly, Type 2 DM
- Profound dehydration
- Confusion ? coma
- No Kussmaul breathing
- No significant acidosis

### ? Laboratory Findings

- Blood glucose: **>600 mg/dL** (often >1000 mg/dL)
- pH: **>7.3**

- HCO?? **>18**
- Ketones: absent or mild
- Serum osmolality: **>320 mOsm/kg**

**? Management**

- Aggressive IV fluids
- Insulin (lower dose than DKA)
- Electrolyte replacement

---

## ? DKA vs HHS (Super High Yield)

| FEATURE | DKA | HHS |
|---|---|---|
| Type | Type 1 | Type 2 |
| Glucose | 250–600 | >600 |
| Ketones | Present | Absent/mild |
| pH | <7.3 | >7.3 |
| Osmolality | Mild ? | Very high ? |
| Onset | Rapid | Slow (days) |
| Mortality | Lower | Higher |

---

## ? LACTIC ACIDOSIS

### ? Definition

Accumulation of **lactic acid** ? **high anion gap metabolic acidosis**.

### ? Causes (Important)

#### Type A (hypoxic)

- Shock
- Sepsis
- Severe anemia
- Cardiac failure
- Hypoxia
- Carbon monoxide poisoning

#### Type B (non-hypoxic)

- Metformin
- Alcohol
- Liver disease
- Malignancies
- Drugs/toxins

### ? Clinical Features

- Deep breathing
- Hypotension
- Severe acidosis
- Altered sensorium

**? Lab Findings**

- Lactate **> 5 mmol/L**
- pH **< 7.35**
- High anion gap metabolic acidosis

---

## ? CHRONIC COMPLICATIONS OF DIABETES

---

### ? 1. Microvascular Complications

**? Retinopathy**

- Non-proliferative ? microaneurysms, hemorrhages
- Proliferative ? neovascularization
- Risk increased by poor glycemic control

**? Nephropathy**

- Microalbuminuria ? macroalbuminuria ? CKD

- Kimmelstiel-Wilson nodules (nodular glomerulosclerosis)

**? Neuropathy**

- Peripheral (glove-and-stocking)
- Autonomic ? gastroparesis, impotence, orthostatic hypotension

---

## ? 2. Macrovascular Complications

- Coronary artery disease
- Cerebrovascular disease (stroke)
- Peripheral arterial disease

---

## ? 3. Other Complications

- Foot ulcers
- Infections (skin, UTI, candidiasis)
- Gastroparesis
- Diabetic dermopathy
- Erectile dysfunction

---

## ? GLYCATED HEMOGLOBIN (HbA1c)

### ? What is HbA1c?

- Glycosylation of hemoglobin at **N-terminal valine of ?-chain**
- Reflects **average glucose over 8–12 weeks**

### ? Normal & Diagnostic Values

- Normal: **<5.7%**
- Pre-diabetes: **5.7–6.4%**
- Diabetes: **?6.5%**

### ? Therapeutic Target

- Most patients: **<7%**
- Stringent control (<6.5%) in young adults
- Lenient control (<8%) in elderly/comorbid

### ? Advantages

- No fasting required
- Reflects long-term control
- Useful for treatment monitoring

### ? Limitations

False values in:

- Hemolytic anemia
- Hemoglobinopathies
- Recent blood transfusion
- Chronic kidney disease (carbamylated Hb)

---

## ? Ultra-Short Summary

- **DKA** = Type 1, ketones + acidosis + Kussmaul breathing.
- **HHS** = Type 2, severe hyperglycemia + hyperosmolality, no ketones.
- **Lactic acidosis** = high lactate, high anion gap acidosis.
- **Chronic complications** = microvascular (retina, kidney, nerves), macrovascular (heart, brain, vessels).
- **HbA1c ?6.5%** = diabetes; reflects last 3 months.

## ? FAQS — Regulation of Blood Glucose, Diabetes, GTT, Complications

---

### 1. Why does blood glucose stay within a narrow range?

Because of coordinated actions of **insulin**, **glucagon**, and other counter-regulatory hormones (cortisol, GH, adrenaline).

---

### 2. Which hormone is the most powerful regulator of blood glucose?

**Insulin** — only hormone that lowers glucose.

---

**3. Why is plasma preferred over serum for glucose estimation?**

Serum takes time to clot ? glucose falls due to glycolysis.
Plasma (with fluoride) prevents glycolysis.

---

**4. What is the renal threshold for glucose?**

Around **180 mg/dL**.
Above this ? glucose appears in urine.

---

**5. What is the significance of OGTT?**

Detects early abnormalities in glucose handling: **IGT** and **GDM**.

---

**6. Why do pregnant women often have glucosuria?**

Pregnancy lowers renal threshold ? **benign glucosuria**.

---

**7. What is the difference between IGT and IFG?**

- **IFG** = high fasting glucose
- **IGT** = high 2-hour post-glucose value

---

**8. Why does Type 1 DM cause ketosis, but Type 2 usually does not?**

Type 1 has **absolute insulin deficiency**, so lipolysis is uncontrolled ? ketone production.
Type 2 has **some insulin** which suppresses ketosis.

---

**9. Why does DKA cause Kussmaul breathing?**

Because metabolic acidosis stimulates respiratory compensation ? deep rapid breathing.

---

**10. Why doesn’t HHS have significant ketosis?**

Presence of **enough insulin** to inhibit ketogenesis.

---

**11. Why is lactic acidosis common in shock?**

Poor tissue perfusion ? anaerobic glycolysis ? excess lactate.

---

**12. What is the earliest marker of diabetic nephropathy?**

**Microalbuminuria** (30–300 mg/day).

---

**13. Why is HbA1c a good long-term marker?**

RBC lifespan = **120 days**, so glycation reflects ~3-month glucose.

---

**14. Can HbA1c be used in anemia?**

No — hemolysis, transfusions, and CKD can give **false results**.

---

**15. Why does diabetes cause infections?**

High glucose impairs neutrophil function, circulation, and immunity.

---

**16. Why do diabetics get foot ulcers?**

Combination of:

- Peripheral neuropathy
- Poor blood supply
- Infection
- Loss of sensation

---

**17. Why is postprandial glucose more important for heart disease risk?**

Post-meal hyperglycemia produces oxidative stress ? endothelial damage.

---

**18. What is the biochemical basis of weight loss in Type 1 DM?**

No insulin ? lipolysis and proteolysis ? muscle and fat loss.

---

**19. Why do diabetics have polyuria?**

Osmotic diuresis due to **glucose in urine**.

---

**20. Why do patients with DKA have normal or high potassium initially?**

Acidosis shifts K? **out of cells**, but total body K? is low.

---

## ? IMPORTANT POINTS TO REMEMBER — ENTIRE CHAPTER

These are the most exam-relevant statements for rapid recall.

---

### ? REGULATION OF BLOOD GLUCOSE

- **Insulin is the only hypoglycemic hormone**; all others raise glucose.
- GLUT-4 is insulin-dependent (muscle + adipose).
- Liver controls fasting glucose via **glycogenolysis** and **gluconeogenesis**.

---

### ? GLUCOSE TESTING

- Fluoride inhibits glycolysis.

- **GOD–POD** is the most common method; **hexokinase** is the reference method.
- Glucometers use **glucose oxidase** or **glucose dehydrogenase**.

---

## ? OGTT / IGT / IFG

- OGTT uses **75 g glucose**.
- IFG = fasting **100–125 mg/dL**.
- IGT = 2-hour **140–199 mg/dL**.
- Diabetes = 2-hour **?200 mg/dL**.

---

## ? DIABETES MELLITUS

- Type 1: autoimmune, ketosis-prone, low C-peptide.
- Type 2: insulin resistance, associated with obesity, acanthosis nigricans.
- Diagnostic criteria:
    - Fasting ?126
    - Random ?200
    - 2 hr OGTT ?200
    - HbA1c ?6.5%

## ? ACUTE COMPLICATIONS

- **DKA**: Type 1, ketones + metabolic acidosis + Kussmaul breathing.
- **HHS**: Type 2, very high sugars, hyperosmolarity, no ketones.
- **Lactic acidosis**: lactate >5 mmol/L, high anion gap.

---

## ? CHRONIC COMPLICATIONS

**? Microvascular:**

- Retinopathy
- Nephropathy (first sign = microalbuminuria)
- Neuropathy (stocking–glove)

**? Macrovascular:**

- CAD, Stroke, PAD

**? Others:**

- Foot ulcers
- Infections
- Gastroparesis

- Erectile dysfunction

---

## ? GLYCATED HEMOGLOBIN (HbA1c)

- Reflects 3-month glucose.
- Target in most diabetics: **<7%**.
- False low: hemolysis, blood loss, CKD.
- False high: iron deficiency anemia.

---

## ? GLUCOSURIA

- Renal glucosuria: tubular defect (SGLT2).
- Alimentary glucosuria: transient after heavy carbs.
- Diabetic glucosuria: blood glucose > renal threshold.

---

## ? GDM

- Occurs due to **pregnancy-induced insulin resistance**.
- Diagnosed by 75 g OGTT at **24–28 weeks**.

---

## ? ULTRA-SHORT EXAM PEARLS

- **HbA1c ?6.5% = diabetes.**
- **IGT = 2-hour 140–199 mg/dL; IFG = 100–125 mg/dL.**
- **DKA ? ketones + acidosis + dehydration.**
- **HHS ? glucose >600 mg/dL, osmolality >320, no ketosis.**
- **Microalbuminuria = earliest sign of nephropathy.**
- **Post-prandial glucose predicts CV risk better than fasting.**
- **Type 1 = autoimmunity (GAD antibodies).**

## ? MCQs — Regulation of Blood Glucose & Diabetes

---

**1. The only hypoglycemic hormone in the body is:**

A. Glucagon
B. Cortisol
C. Growth hormone
D. Insulin

**Answer: D. Insulin**

---

**2. GLUT-4 is stimulated by:**

A. Glucagon
B. Insulin
C. Cortisol
D. Thyroxine

**Answer: B. Insulin**

---

**3. The reference method for glucose estimation is:**

A. GOD–POD
B. Hexokinase
C. Benedict’s test
D. Glucose oxidase strip

**Answer: B. Hexokinase**

---

**4. In OGTT, the glucose load used for adults is:**

A. 50 g
B. 60 g
C. 75 g
D. 100 g

**Answer: C. 75 g**

---

**5. Fasting glucose 110 mg/dL and 2-hour glucose 118 mg/dL indicates:**

A. Diabetes mellitus
B. Impaired fasting glycemia
C. Impaired glucose tolerance
D. Normal

**Answer: B. Impaired fasting glycemia**

---

**6. Fasting glucose 98 mg/dL and 2-hour glucose 165 mg/dL indicates:**

A. Normal
B. Diabetes
C. IGT
D. Renal glucosuria

**Answer: C. IGT**

---

**7. Diagnostic HbA1c value for diabetes is:**

A. >5.7%

B. >6.0%

C. ?6.5%

D. ?7.0%

**Answer: C. ?6.5%**

---

**8. Which hormone shows anti-insulin action?**

A. Calcitonin

B. Cortisol

C. Oxytocin

D. ADH

**Answer: B. Cortisol**

---

**9. Renal threshold for glucose is approximately:**

A. 90 mg/dL

B. 140 mg/dL

C. 180 mg/dL

D. 220 mg/dL

**Answer: C. 180 mg/dL**

---

**10. Glycosuria with normal blood glucose suggests:**

A. Type 2 DM

B. Type 1 DM

C. Renal glucosuria

D. Uncontrolled DKA

**Answer: C. Renal glucosuria**

---

## ? MCQs — DKA, HHS, Lactic Acidosis

---

**11. Most common trigger for DKA:**

A. Exercise
B. High-fat meal
C. Infection
D. Dehydration

**Answer: C. Infection**

---

**12. Which laboratory finding is characteristic of DKA?**

A. pH > 7.4
B. HCO?? > 20
C. High anion gap metabolic acidosis
D. Low ketones

**Answer: C. High anion gap metabolic acidosis**

---

**13. A diabetic patient with glucose 950 mg/dL, no ketones, and osmolality 335 mOsm/kg most likely has:**

A. DKA
B. HHS (Hyperosmolar state)
C. Lactic acidosis
D. Hypoglycemia

**Answer: B. HHS**

---

**14. Kussmaul breathing is characteristic of:**

A. Hypoglycemia
B. HHS
C. DKA
D. Renal glycosuria

**Answer: C. DKA**

---

**15. Lactic acidosis occurs when lactate exceeds:**

A. 1 mmol/L
B. 2 mmol/L
C. 3 mmol/L
D. 5 mmol/L

**Answer: D. 5 mmol/L**

---

## ? MCQs — GDM, Glucosuria, Complications

---

**16. Screening test for GDM at 24–28 weeks is:**

A. Fasting glucose
B. HbA1c
C. 75 g OGTT
D. Random glucose

**Answer: C. 75 g OGTT**

---

**17. Alimentary glucosuria occurs due to:**

A. Diabetes mellitus
B. Kidney disease
C. High carbohydrate meal
D. Fanconi syndrome

**Answer: C. High carbohydrate meal**

---

**18. Earliest manifestation of diabetic nephropathy is:**

A. Proteinuria
B. Edema
C. Microalbuminuria
D. Reduced GFR

**Answer: C. Microalbuminuria**

**19. Which is NOT a microvascular complication of DM?**

A. Retinopathy
B. Neuropathy
C. Nephropathy
D. Coronary artery disease

**Answer: D. Coronary artery disease**
*(Macrovascular.)*

---

**20. HbA1c indicates glycemia over the past:**

A. 1 week
B. 2 weeks
C. 1 month
D. 2–3 months

**Answer: D. 2–3 months**

---

## ? More Clinical MCQs

---

**21. Which type of DM has low C-peptide levels?**

A. Type 2
B. LADA
C. Type 1
D. MODY

**Answer: C. Type 1**

---

**22. Presence of ketones in urine is most typical of:**

A. Type 2 DM
B. Renal failure
C. Type 1 DM
D. Alimentary glucosuria

**Answer: C. Type 1 DM**

---

**23. Hyperosmolar nonketotic coma is characterized by:**

A. Severe ketosis
B. Glucose < 200 mg/dL
C. Severe dehydration
D. Low serum osmolality

**Answer: C. Severe dehydration**

---

**24. Which hormone increases gluconeogenesis?**

A. Insulin
B. Aldosterone
C. Glucagon
D. Thyroxine

**Answer: C. Glucagon**

---

**25. Best indicator of long-term glycemic control is:**

A. Fasting glucose
B. Postprandial glucose
C. HbA1c
D. Random glucose

**Answer: C. HbA1c**

## ? CLINICAL CASE–BASED QUESTIONS (Expanded Set)

---

### ? 1. Polyuria, Polydipsia, Weight Loss

A 17-year-old boy presents with 3 weeks of polyuria, excessive thirst, fatigue, and weight loss. Random glucose is 320 mg/dL. Urine ketones are positive.

**Diagnosis:**
?? **Type 1 Diabetes Mellitus**

**Reason:**
Hyperglycemia + weight loss + ketosis strongly suggest Type 1 DM.

---

### ? 2. Borderline Fasting Sugar

A 45-year-old sedentary man has:

- Fasting glucose: 112 mg/dL
- 2-hour OGTT: 125 mg/dL
- HbA1c: 5.8%

**Diagnosis:**
?? **Impaired Fasting Glycemia (IFG)**

---

### ? 3. Abnormal OGTT

A 50-year-old woman undergoes OGTT:

- Fasting: 95 mg/dL
- 2-hour: 172 mg/dL

**Diagnosis:**
?? **Impaired Glucose Tolerance (IGT)**

---

### ? 4. Late Presentation with Very High Sugar

A 70-year-old diabetic woman presents with lethargy, dehydration, and confusion.
Investigations:

- Glucose: 880 mg/dL
- Serum osmolality: 340 mOsm/kg
- pH: 7.38
- No ketones

**Diagnosis:**
?? **Hyperosmolar Hyperglycemic State (HHS)**

---

### ? 5. Kussmaul Breathing + Acidosis

A 21-year-old Type 1 diabetic skipped insulin. Now breathing deeply and rapidly (Kussmaul).
Lab:

- Glucose: 420 mg/dL
- pH: 7.12
- HCO??: 10
- Ketones: Positive

**Diagnosis:**
?? **Diabetic Ketoacidosis (DKA)**

---

### ? 6. High Lactate in Shock

A 60-year-old man in septic shock shows:

- Lactate: 8 mmol/L
- pH: 7.21
- High anion gap acidosis

**Diagnosis:**
?? **Lactic Acidosis (Type A)** due to hypoperfusion.

---

### ? 7. Recurrent Infections + High HbA1c

A 52-year-old obese man has recurrent fungal infections.
HbA1c = 9.8%

**Interpretation:**
?? Poor glycemic control over the last 3 months.

---

### ? 8. Pregnancy With Failed OGTT

28-year-old pregnant woman at 26 weeks:

- Fasting = 95 mg/dL
- 1 hr = 182 mg/dL

- 2 hr = 168 mg/dL

**Diagnosis:**
?? **Gestational Diabetes Mellitus (GDM)**

---

### ? 9. Clear Glycosuria With Normal Glucose

A 20-year-old woman:

- Fasting glucose: 88 mg/dL
- Urine glucose: positive
- OGTT: normal

**Diagnosis:**
?? **Renal Glucosuria** (tubular SGLT2 defect)

---

### ? 10. Glucosuria After Eating Sweets

A boy eats a lot of sweets at a party. Urine next morning shows glucose.
Fasting sugar = 90 mg/dL.

**Diagnosis:**
?? **Alimentary Glucosuria** (benign)

---

### ? 11. Diabetic With Acute Belly Pain

A 34-year-old diabetic on SGLT2 inhibitors presents with abdominal pain, nausea, and ketonuria but glucose of only 180 mg/dL.

**Diagnosis:**

?? **Euglycemic DKA** (SGLT2 inhibitor–related)

---

### ? 12. Long-Standing Diabetes With Numb Feet

A 60-year-old diabetic complains of burning sensation and loss of vibration sense in feet.

**Diagnosis:**

?? **Diabetic Peripheral Neuropathy**

---

### ? 13. Vision Problems in a Diabetic

A 48-year-old diabetic has blurred vision. Fundus: microaneurysms & cotton-wool spots.

**Diagnosis:**

?? **Non-proliferative Diabetic Retinopathy**

---

### ? 14. Frothy Urine With Microalbuminuria

A 55-year-old diabetic has urine albumin: 75 mg/day.

**Diagnosis:**

?? **Early Diabetic Nephropathy (Microalbuminuria)**

---

### ? 15. Chronic Smoker With High HbA1c but Normal Glucose

A smoker has:

- HbA1c: 7.0%
- Fasting glucose: 95 mg/dL

- Fructosamine: normal

**Reason:**
?? **Falsely high HbA1c** (carbonylation / hemoglobin abnormalities)

---

### ? 16. Hypoglycemia in a Non-Diabetic

A 45-year-old man has recurrent hypoglycemia.
Insulin: High
C-peptide: High

**Diagnosis:**
?? **Insulinoma**

---

### ? 17. Ketoacidosis Without Hyperglycemia

A chronic alcoholic presents with:

- Ketones high
- Glucose normal
- pH: 7.19

**Diagnosis:**
?? **Alcoholic Ketoacidosis**

---

### ? 18. Diabetic With Non-Healing Foot Ulcer

A 64-year-old diabetic has a chronic foot ulcer with reduced pulses in the limb.

**Diagnosis:**
?? **Peripheral Arterial Disease (macrovascular complication)**

---

### ? 19. Abdominal Obesity + High BP + High TG + Fasting Glucose 115 mg/dL

**Diagnosis:**
?? **Metabolic Syndrome (Syndrome X)**

---

### ? 20. Diabetes Suspected but HbA1c Normal

A 25-year-old has:

- HbA1c = 4.8%
- Recurrent osmotic symptoms
- Fasting glucose = 142 mg/dL

**Diagnosis:**
?? **Diabetes** (HbA1c misleading due to hemolysis/high RBC turnover)

---

### ? 21. Extremely High HbA1c in Iron Deficiency

A woman with anemia has:

- HbA1c = 12.4%
- Fasting glucose = 115 mg/dL

**Interpretation:**
?? **False high HbA1c** due to prolonged RBC survival in iron deficiency.

### ? 22. Vomiting + Deep Breathing + Acetone Smell

A child with newly diagnosed DM has severe dehydration, deep breathing, and fruity breath.

**Diagnosis:**
?? **DKA** (classic presentation)

---

### ? 23. Hyperglycemia + Dehydration + Normal pH

A 70-year-old bedridden diabetic:

- Glucose: 780 mg/dL
- Osmolality: 345 mOsm/kg
- pH: 7.39
- Ketones: none

**Diagnosis:**
?? **HHS (Hyperosmolar state)**

---

### ? 24. High Lactate in Metformin User

A 62-year-old diabetic on metformin has:

- Lactate: 7.2 mmol/L
- pH: 7.19

**Diagnosis:**

?? **Metformin-induced lactic acidosis**

---

### ? 25. Sudden Visual Loss in Diabetic

Fundus: vitreous hemorrhage, neovascularization.

**Diagnosis:**

?? **Proliferative Diabetic Retinopathy**

## ? VIVA VOCE — Regulation of Blood Glucose & Diabetes (Whole Chapter)

---

**1. What is the normal fasting blood glucose level?**

70–110 mg/dL.

---

**2. Which hormone lowers blood glucose?**

Insulin (the only hypoglycemic hormone).

---

**3. What is the primary organ regulating blood glucose?**

The liver.

---

**4. Which glucose transporter is insulin-dependent?**

GLUT-4 (muscle and adipose tissue).

---

**5. What is the renal threshold for glucose?**

Around 180 mg/dL.

---

**6. Which is the reference method for glucose estimation?**

Hexokinase method.

---

**7. Why is fluoride used in blood glucose sampling?**

It inhibits glycolysis (preserves glucose).

---

**8. What is OGTT used for?**

Diagnosing diabetes, IGT, and GDM.

---

**9. How much glucose is used in OGTT?**

75 g anhydrous glucose.

---

**10. Define Impaired Fasting Glycemia.**

Fasting glucose 100–125 mg/dL.

---

**11. Define Impaired Glucose Tolerance.**

2-hour OGTT value 140–199 mg/dL.

---

**12. Diagnostic criteria for diabetes (OGTT).**

2-hour plasma glucose ?200 mg/dL.

---

**13. What is HbA1c?**

Glycation of hemoglobin that reflects 2–3 months' average blood glucose.

---

**14. HbA1c diagnostic cut-off for diabetes?**

?6.5%.

---

**15. What conditions make HbA1c unreliable?**

Hemolysis, recent transfusion, anemia, CKD.

---

**16. What are the “3 Ps” of diabetes?**

Polyuria, polydipsia, polyphagia.

---

**17. Why does polyuria occur in diabetes?**

Osmotic diuresis due to glucose in urine.

---

**18. Which type of diabetes is ketosis-prone?**

Type 1 diabetes.

---

**19. What is C-peptide used for?**

Assess endogenous insulin production.

---

**20. What is the biochemical cause of weight loss in Type 1 DM?**

Fat and muscle breakdown due to absence of insulin.

---

**21. What is the earliest sign of diabetic nephropathy?**

Microalbuminuria.

---

**22. What are the microvascular complications of diabetes?**

Retinopathy, nephropathy, neuropathy.

---

**23. What are the macrovascular complications?**

CAD, stroke, peripheral arterial disease.

---

**24. What is the cause of diabetic retinopathy?**

Chronic hyperglycemia damaging retinal vessels.

---

**25. What is the cause of diabetic neuropathy?**

Sorbitol accumulation + microvascular ischemia.

---

**26. Why does diabetes cause infections?**

Impaired immunity and high glucose environment.

---

**27. Describe the mechanism of DKA.**

Insulin deficiency ? lipolysis ? ketone production ? metabolic acidosis.

---

**28. Clinical sign of DKA respiration?**

Kussmaul breathing (deep, rapid).

---

**29. What is the typical pH in DKA?**

<7.3.

---

**30. Characteristic lab finding in DKA?**

High anion gap metabolic acidosis.

---

**31. Why does potassium fall during treatment of DKA?**

Insulin drives K? into cells.

---

**32. Why doesn’t HHS have ketones?**

Enough insulin present to block ketogenesis.

---

**33. Typical glucose level in HHS?**

600 mg/dL (often >1000 mg/dL).

---

**34. Major complication of HHS?**

Severe dehydration and hyperosmolarity leading to coma.

---

**35. What is serum osmolality in HHS?**

320 mOsm/kg.

---

**36. What is lactic acidosis?**

Accumulation of lactate causing metabolic acidosis.

---

**37. Common cause of lactic acidosis in diabetics?**

Metformin (especially in renal failure).

---

**38. Why does shock cause lactic acidosis?**

Tissue hypoxia ? anaerobic glycolysis ? lactate accumulation.

---

**39. What is gestational diabetes?**

Glucose intolerance first diagnosed in pregnancy.

---

**40. Screening test for GDM?**

75 g OGTT at 24–28 weeks.

---

**41. Why do pregnant women have glucosuria?**

Lowered renal threshold for glucose.

---

**42. What is renal glucosuria?**

Glucose in urine despite normal blood glucose due to tubular SGLT2 defect.

---

**43. What is alimentary glucosuria?**

Glucosuria after heavy carbohydrate intake (benign; transient).

---

**44. Why does diabetes cause retinopathy?**

Protein kinase C activation and microvascular damage.

---

**45. Why does hyperglycemia increase cardiovascular risk?**

Endothelial dysfunction + accelerated atherosclerosis.

---

**46. Why is post-prandial glucose important?**

Strong predictor of atherosclerosis and cardiovascular events.

---

**47. What is metabolic syndrome?**

Obesity + high BP + high TG + low HDL + high fasting glucose.

---

**48. What is euglycemic DKA?**

DKA with near-normal glucose (seen with SGLT2 inhibitors).

---

**49. What biochemical test confirms ongoing hemolysis in diabetics?**

Elevated LDH + low haptoglobin.

---

**50. Why is fructosamine used?**

Short-term glycemic control marker (2–3 weeks).