# GLUCOSE METABOLISM

# Blood glucose

- Normal blood glucose: 3,3 - 5,6 mmol/l
- Hyperglycaemia: > 5,6 mmol/l
  - 5,7 - 7,0: impaired fasting glucose
  - > 7,0: diabetes mellitus
- Hypoglycaemie: < 3,3 mmol/l

# Hypoglycaemia - symptoms

- Autonomic symptoms (< 3.0 mmol/l)
  - ↑ counterregulation hormone secretion
    - ⋆Adrenalin
  - Sweating, tremor, sensation of hunger

- CNS symptoms (< 2.2 mmol/l)
  - Inadequate supply of the brain with glucose
  - Impaired cognitive function, unconsciousness

# Causes of fasting hypoglycaemia

- Drugs
  - Insulin, oral hypoglycemic drugs
- With ↑ c-peptide level
  - Insulinoma
- With normal c-peptide level
  - Lack of insulin antagonists
    - ★ Cortisol, growth hormone, glucagone, thyroxin
  - Lack of precursors of glucose
    - ★ Uraemia, sepsis, hepatic coma, kachexia, glycogenosis

# Causes of postprandial hypoglycaemia

- Dumping syndrome
  - 2-4 hours after food intake
  - Gastrectomy (Billroth II)

- Inherent diseases
  - Hereditary fructose intolerance
  - Galactosemia

# Hyperglycaemia - symptoms

- Fasting > 5.6 mmol/l)
- Postprandial > 11.0 mmol/l

- Asymptomatic
  - 5.7 - 11.0 (approx.)
- Symptomatic
  - > 11 mmol/l - glycosuria

# Hyperglycaemia - couses

- Diabetes mellitus type 1
  - Autoimmune - destruction of β-cells in pancreas
  - Idiopathic
- Diabetes mellitus type 2 (insulino-resistance)
  - 95% of diabetics
- Diabetes mellitus in pregnancy
- Other types of diabetes
- Border-live glucose disorders
  - Impaired glucose tolerance
  - Impaired fasting glucose

# Other types of diabetes

- Pancreas diseases
  - Pancreatitis, pancreatectomy
- Liver disease
  - Chronic hepatitis, cirrhosis
- Hereditary hemochromatosis
- Endocrine diseases (hypersecretion of insulin antagonists)
  - Acromegaly (growth hormone)
  - Cushing sy. (glucocorticoides)
    - ★ Chronic glucocorticoide therapy
  - Hyperthyreoidism
  - Glucagonoma (glucagon)

# Diagnostic DM

- Glycaemia - only 1 laboratory analysis
  - Fasting glycaemia > 7,0 mmol/l
  - Postprandial glycaemia > 11,0 mmol/l
  - + typical symptoms
    - ★Polyuria, thirst, weight loss
- Glycaemia - at least 2 laboratory analysis
  - The same, but without clinical symptoms
- Glucose tolerance test

# Glucose tolerance test (GTT)

- When to do it ?
  - Fasting glycaemia 5.7 - 7.0 mmol/l
- When not to do it ?
  - Fasting glycaemia > 7.0 mmol/l
- How to do it ?
  - 75 gr. of glucose p. o.
  - Glycaemia: before, after 2 hours

# Glucose tolerance test (GTT)

- IGT
  - Fasting gl. 5.7 - 7.0 mmol/l
  - 2 hours 7.0 - 11.0 mmol/l
- DM
  - Fasting gl. > 7.0 mmol/l
  - 2 hours > 11.0 mmol/l
- IFG
  - Fasting gl. 5.7 - 7.0 mmol/l
  - 2 hours ≤ 7.0 mmol/l

# Metabolic disorders in DM

# Insulin

- Anabolic hormone
  - Secretion mainly after meal
- Metabolism of
  - Glucose
  - Lipids
  - Proteins
  - Minerals
  - Water

# Insulin and glucose

- Uptake of G in the liver
- Synthesis or degradation of glycogen
- Gluconeogenese
- Uptake of G into cells
  - Muscle cells, adipocytes

# DM and glucose

- Lack of insulin or insulinoresistance
- Hyperglycaemia
  - ↑ gluconeogenesis
  - ↓ synthesis of glycogen
  - ↑ degradation of glycogen
  - ↓ liver uptake of G from the portal blood
  - ↓ uptake of G by muscle and adipose cells

# Insulin and lipids

- Insulin ↑ lipoprotein lipase activity
  - Vascular endothelium
- Insulin deficiency or insulinoresistance
  - ↓ activity of LPL
  - Triglycerides are not split off from VLDL
  - Hypertriglyceridemia occurs

# Insulin and lipids

- Insulin ↓ activity of hormone sensitive lipase (HSL)
  - HSL - in the adipocytes (tissue lipase)
- Insulin deficiency
  - ↑ activity of HSL
  - Splitting off triglycerides, fatty acids are released in to the circulation
  - Liver: ↑ ketone production
    - ⋆Ketoacidosis, ketonuria

# Insulin and proteins

- Insulin stimulates
  - Transport of aminoacids to the cells
  - Synthesis of proteins
- Insulin deficiency
  - Catabolism of the proteins is induced
  - Aminoacids are released and transported to the liver
    - ⋆ Glucoplastic aminoacids $\rightarrow$ glucose, enhanced hyperglycemia
    - ⋆ Ketoplastic aminoacids $\rightarrow$ ketoacids, enhanced ketoacidosis

# Insulin and water

- Osmotic diuresis results in massive water losses
- Other water loss
  - Hyperventilation
  - Vomiting
- The results of water loss
  - Hypovolemia, hypotension
  - Hypoperfusion of kidney

# Insulin and mineral metabolism

- K and insulin deficiency
  - K is released from the cells
  - Hyperkalemia
  - K in urine
  - K deficit may be up to 5-10 mmol/kg body weight
- Na
  - Osmotic diuresis = massive Na loss
- Osmolality
  - ↑ (water loss, hyperglycaemia)

# Laboratory tests in diabetic patients

# Laboratory tests in diabetic patients

- Glykosuria
  - Only for „self monitoring“
  - No significant for treatment nor for diagnosis

- Ketonuria (ketone bodies in the urine)
  - Sign of diabetes decompensation
  - Self monitoring

# Laboratory tests in diabetic patients

- HbA1c - Glycated hemoglobin
  - The „average blood glucose concentration“ during the preceding 6-8 weeks
  - < 4.5 %

- C-peptide
  - Indicator of the insulin secretion
    - ★ DM type 1 x DM type 2
      - ➔Hyperinsulinaemia, insulinoresistance
    - ★ 0.7 - 2.0 μg/l

# Laboratory tests in diabetic patients

- Microalbuminuria
  - Albumin excretion in the urine
  - An early indicator of diabetic microangiopathy, especially diabetic nephropathy
  - 30  - 300 mg/24 hours
  - 2 x a year

- Blood lipids
  - Cholesterol, triglycerides
  - Risk of diabetic macroangiopathy, CHD