PANCREAS

SECRETIONS OF THE PANCREAS

Pancreas has both digestive and endocrine functions

Digestive secretions of the pancreas are called pancreatic juices

Entrance of pancreatic juice into the duodenum is controlled by sphincters of the pancreatic duct

ENDOCRINE FUNCTION OF THE PANCREAS

Islets of Langerhans serve as the clusters of cells which have and endocrine function

Islets secrete: Insulin (Beta cells) Glucagon (Alpha cells) Somatostatin

EXOCRINE FUNCTION OF THE PANCREAS

Acinar cells serve as cells of function which secrete enzymes

Duct cells serve to secrete electrolyte solutions

PANCREATIC SECRETION

Most pancreatic secretion occurs after meals approximately 2 Liters per day

Increases in pancreatic secretion after meals are due to:

1) Parasympathetic input

2) Hormones released by the duodenum during entry of chyme into the intestine

PANCREATIC ENZYMES

Acinar cells secrete zymogen granules which are inactive precursors of digestive enzymes which are subsequently activated in the intestine

Storage in an inactive form prevents the enzymes from digesting the acinar cells themselves

1) Proteases: Trypsin, Chymotrypsin, Peptidases specific for breaking peptide bonds

2) Nucleases hydrolyze RNA or DNA to their component molecules

3) Elastases- digest collagen molecules of connective tissue

4) phospholipases- reduce phospholipids to fatty acids

5) lipases- degrade triglycerides into fatty acids and glycerol

6) pancreatic-amylase -digest starches

INTESTINAL ACTIVATOR ENZYME

Enterokinase- enzyme secreted by the intestine which sets in motion the conversion of zymogens to their active forms

DUCT CELLS

CO_2 and H_2O react within the cells to form H_2CO_3 (carbonic acid) which dissociates in water to form H^+ and HCO_3^- (bicarbonate)

H^+ and Na^+ are exchanged from the cell and blood plasma with Na^+ leaking into the pacreatic duct lumen

Na^+ and HCO_3^- combine in the lumen to form $NaHCO_3$ (sodium bicarbonate) which buffers the acid from the stomach

ROLE OF GLUCAGON

Glucagon is secreted from Alpha cells of the islets of Langerhans

Glucagon serves to oppose actions of insulin

Promotes an increase in blood glucose levels by stimulating:

Breakdown of glycogen to glucose

Breakdown of lipids to glucose

Synthesis of glucose from amino acids

ROLE OF INSULIN

Glycogen is a storage form of glucose

Cells store glycogen in the form of granules

ABSORPTIVE STATE

Nutrients enter the bloodstream from the intestine during the absorptive state

Storage of nutrients as glycogen and fats dominate the absorptive state

POST-ABSORPTIVE STATE

During the post-absorptive state nutrients must be made available for cell or body stores temporary storage is reversed during the post-absorptive state

Stored glycogen and fats are broken down and released to supply the body's need for energy

REGULATORY ROLE OF INSULIN

Insulin regulates the entry of glucose and amino acids into cells during the absorptive state

Insulin is released from Beta cells of the islets of Langerhans in the pancreas

Process by which Beta cells release insulin is exocytosis (same as neurotransmitters from nerve cells)

BETA CELLS

Beta cells are the most common cell of the islets of Langerhans

usually found near the center of the pancreas

GLUCOSE CONCENTRATIONS

Normal plasma glucose concentration 80 - 110 mg/dl of plasma or 10 microunits (U/ml)

microunits is an arbitrary unit of measurement

INSULIN SECRETION

The most potent stimulus for insulin secretion is elevated blood glucose levels

Insulin secretion is blocked at plasma glucose conc. of 50 mg/dl

Insulin secretion reaches it maximum at plasma glucose conc. of 300 mg/dl

GLUCOSE RECEPTORS

The number of glucose receptors present on the Beta cells also affect the secretion of insulin

High carbohydrate diets increase the density of glucose receptors on Beta cells conversely as well

BETA CELLS

Beta cells are also stimulated to release insulin in response to:

1) Elevated levels of amino acids in the blood

2) Gastric inhibitory peptide (GIP)

3) Cholecystokinin (CCK)

4) Increased parasympathetic activity

INSULIN FUNCTION

Insulin promotes the use of glucose, amino acids and fats during the absorptive state

Insulin is required for glucose uptake by all cells in the body except: Liver cells, Brain tissue, RBC,Renal medulla (kidney)

Insulin promotes the storage of extra nutrients as: Glycogen, Fat in liver and adipose tissue

insulin also: Stimulates anabolic pathways in the cell and also inhibits catabolic pathways and glucagon secretion

GASTRIC FUNCTION

Gastric mucosa has different types of cells:

- Surface epithelial cells: secrete mucus
- Parietal cells: Secrete HCl (pH 0.8)and Intrinsic factor
- Chief cells: secrete Pepsinogen
- Entero-chromaffin cells: secrete Serotinin
- G-cells: secrete Gastrin [stimulates secretion of HCl, Pepsinogen, Intrinsic factor, Secretin, Pancreatic enzymes, HCO_3^- & Bile. Increases Gastric & Intestinal motility, Increases mucosal growth]
- Other endocrine-secreting cells

- Total Gastric secretion about 2000ml

HCl secretion

- Neurogenic phase of digestion starts with sight, smell and taste of food→ stimulate Cereberal cortex→ stimulate Vagal nuclei→ Acetyl choline secretion from Post ganglionic parasympathetic nerve endings→ stimulation of parietal cells & G-cells→ secretion of HCl & Pepsinogen
- HCl is secreted by Parietal cells under stimulation by Acetyl choline (neurocrine), Histamine (paracrine) and Gastrin (endocrine pathway).
- H^+ secretion into lumen is against 1 million fold Conc. gradient & requires H^+ / K^+ ATPase [pH of ECF= 7.4, pH of Gastric juice= 2]
- Histamine H2 receptor antagonists are used to inhibit acid secretion. Eg. Cimetidine, Ranitidine, Famotidine: they block morphological transformation of Parietal cells preceeding acid secretion.
- Omeprazole is taken up by Parietal cells & inactivates H^+/ K^+ ATPase. Synthesis of new enzyme takes 24 hrs.
- Gastric phase of Digestion begins with distension of Stomach with food: it stimulates secretion of Gastrin & HCl. Gastin stimulates gastric motility & secretion of HCl, Pepsinogen, Pancreatic enzymes, GI hormones (Secretin, Insulin, Somatostatin, Pancreatic polypeptide). Neutralization of existing HCl by food also stimulates HCl secretion.
- Food mixes with gastric secretion and is partly degraded to become Chyme, which moves to Duodenum.
- Inside Parietal cells:
- $CO_2 + H_2O$ ← carbonic anhydrase → H_2CO_3
- H_2CO_3 ← carbonic anhydrase → $H^+ + HCO_3^-$
- 1 K^+ from Gastric lumen is exchanged for 1 H^+ from Parietal cell using 1 ATP
- 1 HCO_3^- from Parietal cell is exchanged for 1 Cl^- from plasma.
- This causes ‘Alkaline tide’ in plasma and urine after meals.
- Cl^- absorbed into Parietal cell is secreted into Gastric lumen.

Role of HCl:

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Denaturation of proteins; optimum pH for digestive enzymes; Activation of Pepsin by partial proteolysis; Absorption of Calcium & Iron.