Hormonal regulation of carbohydrate metabolism

Why glucose concentration should be maintained or regulated?

The normal glucose concentration: 140 mg/dL (postprandial), 70 to 99 mg/dL (pre-prandial). A slight variation of this normal level leads to hyperglycaemia or hypoglycaemia. Thus, the level of glucose is regulated by various hormones.

And this hormonal regulation of carbohydrate metabolism is mainly occurred by the internal chemical messengers. Hormones like insulin, glucagon, epinephrine, cortisol, TH and GH regulates this metabolism.

Insulin: Insulin is a peptide hormone. Secreted by β cells of islets of Langerhans from pancreas. Elevated blood glucose level leads to insulin secretion. The secreted insulin carries various anabolic functions. Thus, maintain high blood glucose in normal range.

Effect of insulin:

- Reduces blood glucose mainly by uptake of glucose by the cells through GLUT 4 glucose transporters.
- In other tissues like Adipose tissue - increases fatty acid and triglyceride synthesis.
  - Decreases lipolysis.
- Liver and muscle - increases glycogen synthesis.
  - Decreases glycogenolysis.

Glucagon: Glucagon is also a peptide hormone secreted by α cells of islets of Langerhans from pancreas. It is an antagonist of insulin which shows the catabolic activities. It is secreted when there is fall in blood glucose level from normal range. Thus, it stops insulin secretion during low blood glucose level. It increases blood glucose mainly by breaking down of stored glycogen and triglycerides.

Effect of glucagon:

- In liver: -Increases glycogenolysis.
  -Increases gluconeogenesis.
  -Increases ketone body synthesis.
  -Decreases glycogen synthesis.
- In muscle: -Increases protein degradation.
  -Decreases protein synthesis.
- In adipose tissue: -Increases lipolysis.
  -Decreases triacylglycerol synthesis.
- The overall effect of glucagon is to stimulate glucose synthesis, use of ketone bodies as fuel for brain and other tissues.

Catecholamines: These are water soluble compounds having role as both hormones and neurotransmitters. e.g. epinephrine, nor-epinephrine, dopamine. Produced in brain and other neuronal tissues acts as neurotransmitters. But this catecholamines produced from adrenal glands acts as hormones.

Epinephrine: The epinephrine is synthesised and secreted from adrenal medulla acts as hormone. It is a fight or flee hormone i.e. it is released during emergency situations. It is an antagonist of insulin which shows the catabolic activities. Released when blood glucose level is low and increases blood glucose level.

Effect of epinephrine:

- In liver - Increases glycogenolysis.
  - Increases gluconeogenesis.
  - Decreases glycogen synthesis.
- In adipose tissue - Increases lipolysis.
- In skeletal muscle - Increases glycogenolysis.

Finally, it stimulates glucagon secretion and inhibits insulin secretion. Thus, utilizing the stored fats and glycogen.

Glucocorticoids:

Cortisol is the primary glucocorticoid in humans. A variety of stimulus releases the cortisol from adrenal cortex. It is also an antagonist of insulin which brings about the catabolic effects and increases blood glucose level to the normal level. In chronic stress cortisol acts to make fuel available to withstand the stress. This hormone is a slow acting hormone which alters metabolism by kinds and amounts of certain enzymes synthesized in its target cells.

Effect of cortisol: Cortisol mainly acts on muscle, liver and adipose tissues and releases glucose.

- In adipose tissue - Increases lipolysis.
- In liver - Increases gluconeogenesis.
  - Increases glycogen break down.
- In muscle - Increases muscle protein breakdown.
  - Decreases protien synthesis.

Thus, the overall effect of cortisol is to break down of stored glycogen and fat to yield glucose

Growth hormone: Growth hormone control various physiological process and metabolism. GH secreted by somatotrophic cells of anterior pituitary gland. It is secreted when the blood glucose level is low from the normal range. When there is less plasma fatty acid level and in increased plasma amino acid level stimulates the secretion of GH. Also, during sleep,

exercise and in stress condition there will be increased secretion of GH. And its secretion is regulated by 2 hypothalamic hormones and one stomach hormone i.e. growth hormone releasing hormone (GHRH), somatostatin and ghrelin.

Effect of growth hormone:

- If the growth hormone secretion is increased it increases plasma glucose concentration also fatty acid and glycerol concentration in the blood.
- It decreases or inhibits the glucose uptake by the adipose tissue and skeletal muscle.
- In adipose tissue - Increases lipolysis thus releasing free fatty acids and glycerol which is mobilized to liver where it leads to gluconeogenesis.
- In liver - Increases gluconeogenesis. - Increases glycogenolysis.

Thyroid hormones: It is a mixture of low molecular weight iodinated tyrosine derivatives i.e. T3 and T4. Secreted from thyroid gland under the control of thyroid stimulating hormone (TSH) by pituitary gland. The normal range of thyroid hormone is 5-12 μg/dL. Above this range leads to hyperthyroidism and below this range leads to hypothyroidism. During these two diseased conditions it shows different effect on carbohydrate metabolism. In hyperthyroidism it shows catabolic activity and in hypothyroidism it shows anabolic activity.

Effect of thyroid hormone: In hyperthyroidism, increases blood glucose by increasing glycogenolysis. In liver, Increases breakdown of muscle proteins. Increases lipolysis. Increases gluconeogenesis and also ketone body synthesis. In hypothyroidism, decreases blood glucose level by increasing glycogenesis. Increases protein synthesis.