Metabolic Response to Trauma

Metabolism

It is the complex system of interrelated biochemical reactions and physiological responses that required for maintaining the life.

Homeostasis:

Homeostasis is an optimum metabolic state that maintains the optimal functioning of the organism

It is a complex process involving the brain, nerves, heart, lungs, kidneys and spleen to maintain body stability.

Stress Response

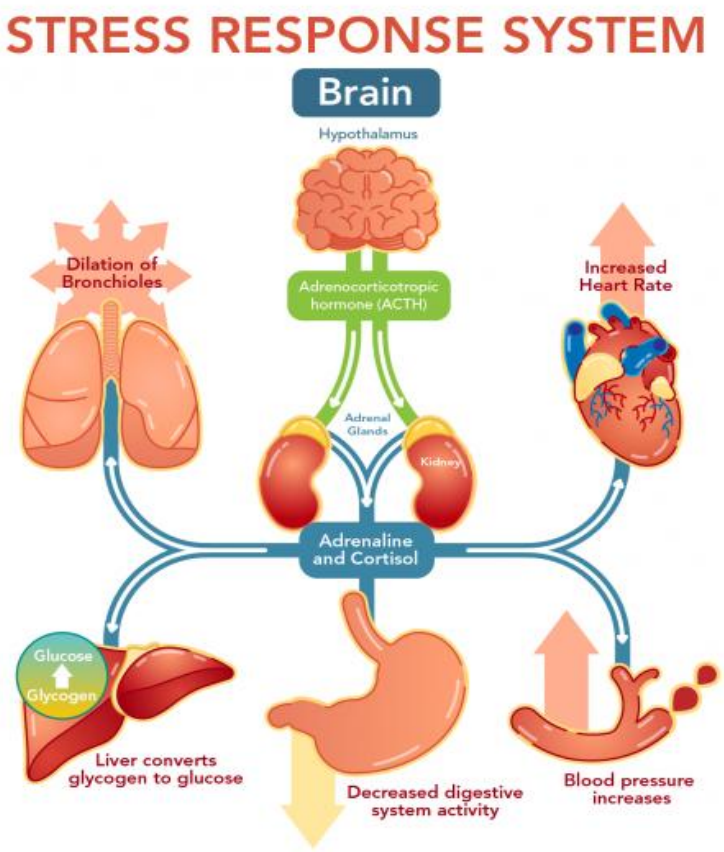
It is the body's damage control system intended to maintain homestasis and to provide substrate for repair of injury.

Traumatic injury is one of the many stimuli that trigger a set of metabolic changes known as the stress response.

Other stimuli include: pain, fear, anxiety, hemorrhage, surgery, and infection.

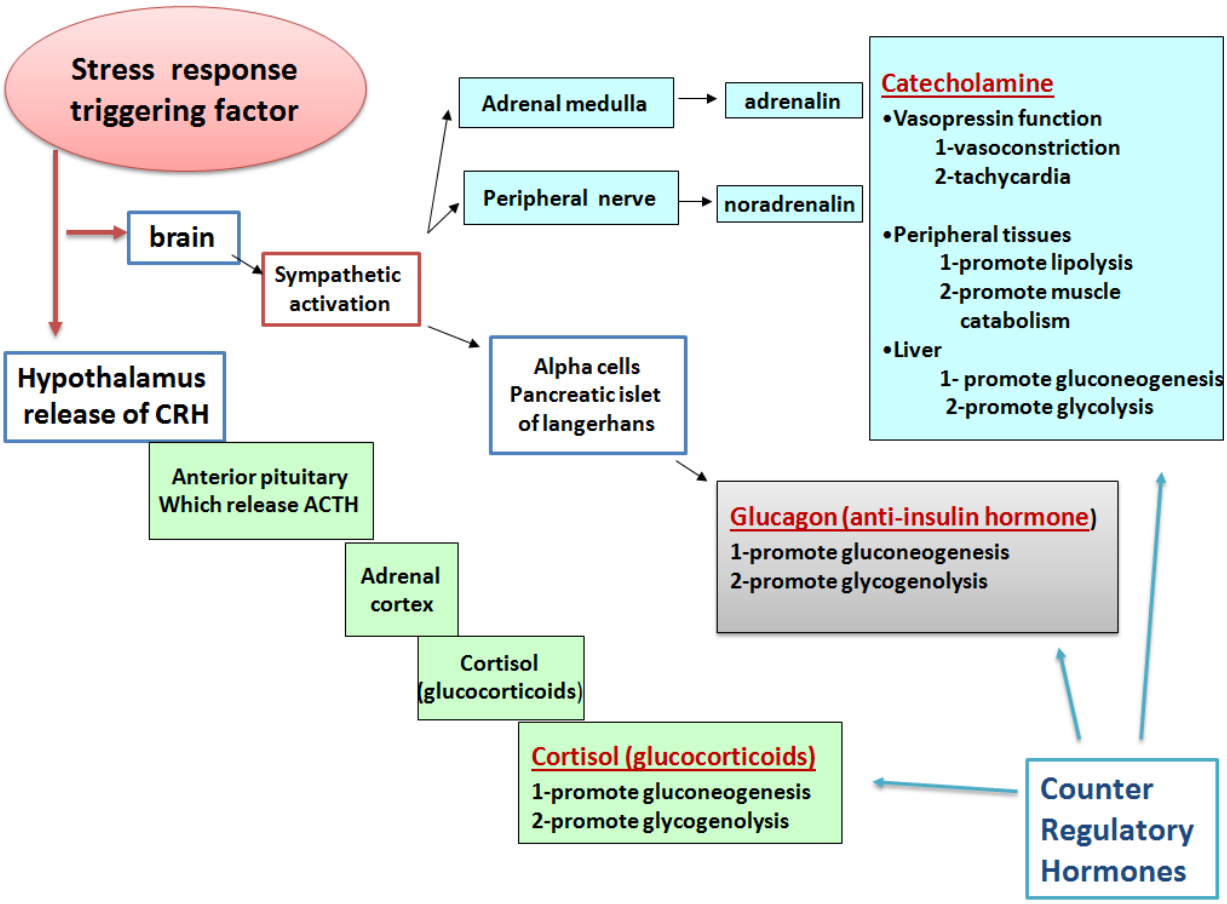
The stress response involves a set of hormonal and inflammatory signals that produces a hypermetabolic state. The hyperglycemia and mobilization of additional energy substrate from muscles and fat stores occur in order to fuel vital body functions.

The stress response has two control arms: ***neuroendocrine*** arm and ***inflammatory*** arm



A-Neuroendocrine arm

- This pathway consists of neural part (Brain, the spinal cord, and afferent neurons) and endocrine part (hypothalamus, pituitary, and adrenal gland).
- Corticotrophin-releasing factor (CRF) released from the hypothalamus increases adrenocorticotrophic hormone (ACTH) release from the anterior pituitary. ACTH then acts on the adrenals to increase the secretion of cortisol.
- Activation of the sympathetic nervous system causes release of adrenaline and also stimulates release of glucagon.
- These 'counter-regulatory' hormones (glucagon, glucocorticoids and catecholamines) have a major role in the metabolic response to injury.



B-Inflammatory arm

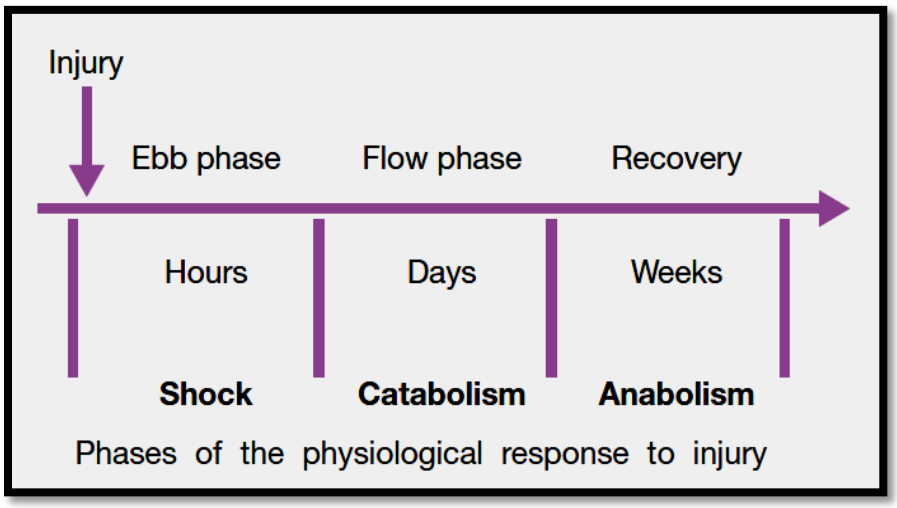
- It is mediated by cytokines. which are chemical messengers released by cells, they are produced within the first 24 hours
- The major cytokines identified as components of the inflammatory response are: interleukin-1 (IL-1), tumour necrosis factor alpha (TNFα), IL-6 and IL-8
- These Cytokines:
  - Act directly on the hypothalamus to cause pyrexia.
  - Act directly on skeletal muscle to induce proteolysis.
  - Also play a complex role in the development of peripheral insulin resistance.
- The inflammatory arm (which is controlled by the cytokines) triggers the immunological response to promote haemostasis, wound healing and control of infection.

Systemic Inflammatory Response Syndrome (SIRS)

The pathological extension of the stress response; is known as **Systemic inflammatory response syndrome (SIRS),** which is characterized by exaggerated response of the body and may progress to **Multiple Organ Dysfunction Syndrome (MODS)**

Phases of the Metabolic Response

The metabolic response to injury in humans is divided into 'ebb' and 'flow' phases.



Phases of the physiological response to injury

The Ebb Phase

- The ebb phase begins at the time of injury and lasts for approximately 24–48 hours.
- It may be attenuated by proper resuscitation, but not completely abolished.
- The ebb phase is characterised by:
  - ✓ Hypovolaemia
  - ✓ Decreased basal metabolic rate
  - ✓ Reduced cardiac output
  - ✓ Hypothermia and lactic acidosis.

- The predominant hormones regulating the ebb phase are catecholamines, cortisol and aldosterone (following activation of the Rennin-Angiotensin-Aldosterone system –RAAS).
- The main physiological role of the ebb phase is to conserve both circulating volume and energy stores for recovery and repair.

The Flow Phase

- Following resuscitation, the ebb phase evolves into a hypermetabolic flow phase, which corresponds to SIRS.
- This phase involves the mobilisation of body energy stores for recovery and repair, and the subsequent replacement of lost or damaged tissue.
- It is characterised by:
  - Tissue oedema (from vasodilatation and increased capillary leakage)
  - Increased basal metabolic rate (hypermetabolism)
  - Increased cardiac output
  - Raised body temperature
  - Leukocytosis,
  - Increased oxygen consumption
  - Increased gluconeogenesis.

- The flow phase may be subdivided into an initial catabolic phase, lasting approximately 3–10 days, followed by an anabolic phase, which may last for weeks. During the catabolic phase, the increased production of counter-regulatory hormones (including catecholamines, cortisol, and glucagon) and inflammatory cytokines results in significant fat and protein mobilisation, leading to significant weight loss. The increased production of insulin at this time is associated with significant insulin resistance and, therefore, injured patients often exhibit poor glycaemic control.

Catabolic elements of the flow phase

It must be remembered that, during the response to injury, not all tissues are catabolic, the body reprioritizes the limited resources away from peripheral tissues (muscle, adipose tissue, skin) and towards key viscera (liver, immune system) and the wound.

1. Hypermetabolism

The majority of trauma patients demonstrate energy expenditures approximately 15–25% above healthy resting values.

2. Alterations in skeletal muscle protein metabolism

Muscle protein is continually synthesised and broken down with a turnover rate in humans of 1–2% per day. Under normal circumstances, synthesis equals breakdown and muscle bulk remains constant. Physiological stimuli that promote muscle protein accretion (increase) include feeding and exercise. Paradoxically, during exercise, skeletal muscle protein synthesis is depressed, but it increases again during rest and feeding.

During the catabolic phase of the stress response, muscle wasting occurs as a result of an increase in muscle protein degradation, coupled with a decrease in muscle protein synthesis. The major site of protein loss is peripheral skeletal muscle.

Clinically, a patient with skeletal muscle wasting will experience asthenia (weakness), increased fatigue, reduced functional ability, decreased quality of life and an increased risk of morbidity and mortality.

3. Insulin resistance

Following surgery or trauma, postoperative hyperglycaemia develops as a result of increased glucose production combined with decreased glucose uptake in peripheral tissues.

Factors that compound the response to injury

1. Volume loss (continuing hemorrhage)
2. Hypothermia
3. Tissue odema
4. Systemic inflammation and tissue underperfusion
5. Starvation
6. Immobility

This is the End of the Lecture – Good Luck