The Metabolic Response To Injury

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why??

Restore tissue function.

Eradicate invading microorganisms.

Basic concepts

Body systems act to maintain internal constancy.

Complex homeostatic responses involving the brain, nerves, heart, lungs, kidneys, & spleen work to maintain body constancy.

Responses to injury are, in general, beneficial to the host & allow healing\survival.

Metabolism During Fasting

A normal healthy adult requires approximately 25 kcal/kg/day from carbohydrates, lipids, & protein.

This requirement can be as high as 40 kcal/kg/day in severe stress states such as those seen in patients with burn injury.

In short term fasting (less than 5 days), the principal sources of fuel are derived from muscle protein & body fat with fat being the most abundant source of energy.

The normal adult body contains 300-400 g of carbohyd. in the form of glycogen. 75-100 g of which are stored in the liver. Approx. 200-250 g of glycogen are stored within skeletal, cardiac, & smooth muscle cells.

It is important to recognize that the response to injury is graded: the more severe the injury the greater the response. This is not only applies to physiological/ metabolic changes but also to immunological changes/ sequelae.

Following elective surgery of intermediate severity ,there may be transient & modest rise in temperature,heart rate, respiratory rate, energy expenditure & peripheral white cell count.

Following major trauma/sepsis, these changes are accentuated, resulting in a SIRS, marked catabolism, shock & even MODS.

Response components

Physiological: increase cardiac output,
ventilation,
& membrane transp

weight loss

wound healing

Metabolic : hypermetab

accel gluconeogenesis

enhanced protein breakdown

increased fat oxidation

Clinical : fever, tachycardia, tachypnea, presence of inflammation, anorexia.

Lab. : leucocytosis/leucopenia, hyperglycemia, elevated CRP/ altered acute phase reactants, hepatic/renal dysfunction.

Mediators of the metabolic response to injury

The classical neuroendocrine pathways of the stress response consist of afferent nociceptive neurones, the spinal cord, thalamus, hypothalamus and pituitary.

The natural response to injury includes:

Immobility/rest

Anorexia

Catabolism

Ebb & flow phases:

ebb phase begins at the time of injury & lasts for approximately 24-48 hours it may be attenuated by proper resuscitation,but not completely abolished.

The ebb phase is characterized by hypovolemia, decreased BMR, reduced cardiac output , hypothermia & lactic acidosis.

The predominant hormones regulating the ebb phase are catecholamines, cortisol & aldosterone.

The magnitude of this neuroendocrine response depends on the degree of blood loss & the stimulation of somatic afferent nerves at the site of injury..

Following resusc., the ebb phase evolves into a hypermetabolic flow phase, which corresponds to the SIRS . This phase involves the mobilisation of body energy stores for recovery & repair & the subsequent replacement of lost or damaged tissue.

It is characterised by tissue oedema, increased BMR , increased cardiac output, raised body temperature, leukocytosis, increased oxygen consumption & increased gluconeogenesis.

Physiol. response

Injury

Ebb phase	Flow phase	Recovery
HOURS	DAYS	WEEKS
Shock	**Catabolism**	**Anabolism**
	breaking down	building up
	energy stores	used energy

During the catabolic phase the increased production of counter-regulatory hormones including (catecholamines , cortisol, insulin & glucagon) & inflammatory cytokines(IL-1,IL-6, & TNFa) results in significant fat & protein mobilisation leading to significant weight loss & increased urinary nitrogen excretion.

Increased insulin at this time is associated with significant insulin resistance lead to poor glycemic control leading to increased risk of complications particularly infectious & cardiovascular.

Purpose of neuroendocrine changes following injury:

Provide essential substrates for survival.

Postpone anabolism.

Optimise host defense.

These changes may be helpful in the short term but may be harmful in the long term especially to the severely injured patient who would otherwise not have survived without medical intervention.

During the response to injury not all tissues are catabolic that is to allow the body to reprioritise limited resources away from peripheral tissues(muscle, adipose tissue, skin) & towards key viscera(liver, immune system,) & the wound.

The majority of trauma patients except those with extensive burn demonstrate energy expenditure approximately 15-25% above predicted healthy resting values.

Patient energy expenditure could rise even higher than observed levels following surgery or trauma but several features of standard intensive care(including bed rest, paralysis, ventilation & external temperature regulation) counteract the hypermetabolic driving forces of the stress response.

The skeletal muscles wasting experienced by patients with prolonged catabolism actually limits the volume of metabolically active tissue.

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. Cardiac muscle appears to be mostly spared.

Under extreme conditions of catabolism(major sepsis) urinary nitrogen losses can reach 14-20g/day equal loss of 500g of skeletal muscle / day.

Clinically a patient with skeletal muscle wasting will experience asthenia, increase fatigue, decrease functional ability, decrease quality of life & increase risk of M. & M.

In response to inflammatory conditions including surgery, trauma, sepsis, cancer or autoimmune conditions , circulating peripheral blood mononuclear cells secrete a range of proinflammatory cytokines including IL-1,6 &TNF a. These cytokines promote the hepatic synthesis of positive acute phase proteins e.g. fibrinogen & c-reactive protein. Albumin fall acutely following injury.

Insulin resistance

Following surgery or trauma, postoperative hyperglycemia develops as a result of increase glucose production combined with decrease glucose uptake in peripheral tissues as a result of insulin resistance.

The degree of insulin resistance is proportional to the magnitude of the injurious process.

Postop. patient with insulin resistance behave in a similar manner to individuals with type II DM & are at increase risk of sepsis, deteriorating renal function, polyneuropathy & death.

Changes in body composition following injury

A normal human ingests about 70-100g protein/ day which is metabolized & excreted in urine as ammonia & urea approx. 14g nitrogen/ day. Following major injury, there is continuing urinary nitrogen losses of 10-20 g nitrogen/day equivalent to 500 g of wet weight lean tissue/ day.

Critically ill patients admitted to the ICU with severe sepsis or major blunt trauma undergo massive changes in body composition.

Body weight increases immediately on resuscitation with an expansion of EC water by 6-10 L within 24 hours.

Thereafter total body protein will diminish by 15% in the next 10 days & body weight will reach negative balance this can be achieved by blocking the neuroendocrine stress response with analgesia & providing early enteral feeding with avoidance of excessive administration of i.v. saline.

The metabolic stress response may be further exacerbated by anesthesia, dehydration, starvation(including preop. fasting) , sepsis, acute medical illness or even severe psychological stress.

Avoidable factors that compound the response to injury:

Continuing hemorrhage.

Hypothermia: results in increase elaboration of adrenal steroids & catecholamines. It also results in 2-3 folds increase in postoperative cardiac arrhythmias & increase catabolism.

Tissue edema.

Tissue underperfusion.

Starvation.

Immobility.

Prevention of unnecessary aspects of the surgical stress response:

Minimal access techniques.

Blockade of afferent painful stimuli.

Minimal periods of starvation.

Early mobilisation