METABOLIC STRESS

Critical illness, severe injury, infection, trauma, and major surgery are serious conditions that may cause profound physiological changes. The term **metabolic stress** refers to the physiological effects of these conditions.

Metabolic stress affects the major body systems in different ways. It inhibits the ability of the immune system to protect against outside invaders, slows wound healing, and may diminish muscle strength. Recovery is enhanced when the patient receives adequate medical and nutritional care to prevent sepsis and organ failure.

Measurement of Metabolic Rate

Metabolism is the sum of all chemical reactions taking place in the body. Oxygen is used in these reactions, and carbon dioxide and heat are produced. When metabolic activity increases, more oxygen is used and more carbon dioxide and heat are produced.

Clinicians measure **metabolic rate** from a person's oxygen uptake under standardized conditions.

Basal metabolic rate (BMR) is a measurement of the metabolic rate under basal conditions. It is the amount of energy (expressed in Cal/day) required to maintain minimal body function of a person in a resting, awake state. The BMR includes energy needed for body functions such as cellular metabolism, breathing, and heart function, and for maintaining body temperature. Energy required for physical activity and digesting food is not included. BMR is measured about 12 hours after a meal, with the person awake and at rest in a comfortable room temperature.

Basal conditions

- The person must not have eaten for at least 12 hours
- The BMR is determined after a night of restful sleep
- No strenuous exercise is performed during the preceding hour or more
- All psychic and physical factors that cause excitement must be eliminated
- The temperature of the air must feel comfortable to the subject and fall between 68° and 80 °F

Resting metabolic rate (RMR) is the amount of energy required to maintain normal body function in a person who is awake and at rest, and has not eaten for a few hours. The RMR is inherently somewhat less accurate than the BMR, but the two measurements usually differ only slightly. The two terms are sometimes used interchangeably.

Factors known to affect the BMR include body mass (higher metabolic rate with leaner body mass) and gender (higher rate in males). To determine how other factors affect metabolic rate, measurements have been taken in patients who are active or digesting food in a variety of room temperatures, and in patients who have recently undergone trauma, burns, or major surgery. Comparing these metabolic rates with basal rates led to the concept of metabolic stress.

Many changes occur during metabolic stress. For instance, the metabolic rate increases (**hypermetabolism**), mediated by hormonal changes. A catabolic state results. As proteins are used for energy, the excretion of breakdown products of protein (urea nitrogen) increases. The immune system is suppressed, possibly due to the release of corticosteroids during stress.

During metabolic stress, the amount of energy needed just to maintain minimal body function can increase by 25% to 100%. Initiating enteral feeding in the early stages can help meet the increased caloric needs and minimize the effects of metabolic stress.

Metabolic stress
- Metabolic rate increases (hypermetabolism), resulting in catabolic state
- Proteins are used for energy
- Immune system is suppressed

Phases of Metabolic Stress

The response to severe injury takes place in three phases. In the **ebb phase**, immediately following injury, metabolic stress begins and energy is conserved. The **flow phase**, which begins after the ebb phase, is further broken down into two phases. In the **acute flow phase**, energy requirements increase, sometimes markedly. In the **adaptive flow phase**, the healing process begins. For optimal recovery, appropriate nutritional support is necessary throughout the three phases.

Phases of Metabolic Stress
- Ebb phase: metabolic stress begins; energy is conserved immediately following injury
- Acute flow phase: energy requirements increase, sometimes markedly
- Adaptive flow phase: healing process begins

The three phases are described below as they occur after a severe injury. The same phases take place in other metabolically stressed states, such as severe infection, but the timing and details of the reactions may differ.

The Ebb Phase

The ebb phase of metabolic stress begins immediately after injury. It may last from 2 to 3 hours up to 24 hours, depending on the type and extent of injury. Both the metabolic rate and energy requirements decrease. Blood pressure and cardiac output (volume of blood flow through the heart) may drop due to blood loss from the injury. Body temperature may fall.

The primary treatment goal during the ebb phase is to prevent multiple organ failure. This involves such steps as restoring adequate blood circulation. Lost blood may be replaced by transfusing either fluids or whole blood. Enteral feeding usually is not provided during the ebb phase; it is typically initiated after the patient's condition has stabilized.

Ebb Phase of Metabolic Stress

- Begins immediately after injury; may last up to 24 hrs
- Metabolic rate and energy requirements decrease
- Blood pressure, cardiac output, and body temperature may drop
- Enteral feeding usually not initiated until patient is hemodynamically stable

The Acute Flow Phase

During the acute flow phase, the body adjusts to the injury. One of the first adjustments is an increase in cardiac output and blood pressure, which stabilize the circulatory system. This is critically important when a large amount of blood has been lost. The endocrine system quickly produces stress hormones (glucagon, catecholamines, and glucocorticoids), increasing the metabolic rate. The increased blood levels of the stress hormones mobilize energy sources and raise the levels of glucose circulating in the blood.

Fat stores and muscle tissue are catabolized (broken down), yielding energy. Up to 80% of this energy is provided by fat stores, and the remainder by muscle tissue.

As muscle tissue is catabolized, protein is broken down into its amino acids. The liver uses the amino acids to produce energy by a process called **gluconeogenesis.** (It converts them to glucose, which is blood sugar).

Acute Flow Phase

- o Cardiac output and blood pressure increase
- o Fat stores and muscles are catabolized, yielding energy
- o Protein in muscle tissue breaks down, providing amino acids for gluconeogenesis in the liver
- o Stress hormones (glucagon, catecholamines, and glucocorticoids) are rapidly produced
- o Levels of circulating glucose rise

The breakdown of muscle tissue after severe injury is essential, to provide amino acids for glucose production, but the consequence is a rapid loss of organic nitrogen and lean body tissue. Also, potassium, phosphorus, and sulfur are lost proportionally to the loss of muscle tissue.

Gluconeogenesis is an extremely important energy pathway. It helps maintain blood levels of glucose under conditions of metabolic stress, and supplies key organs such as the brain with the glucose needed for metabolic reactions.

The acute flow phase generally peaks 3 or 4 days after injury. It ends in 7 to 10 days, if no complications have occurred.

Hyperglycemia (abnormally high blood glucose levels) is common during the acute flow phase of metabolic stress. Glucose production is increased, and metabolic stress apparently causes body cells to become resistant to insulin. The patient may have enough circulating insulin, but the cells' receptor sites, normally "unlocked"' by insulin, have become insensitive. This means the cells remain "locked." Glucose cannot enter, so blood glucose levels rise.

The body continues to call for energy during the hypermetabolic state. This leads to the release of higher levels of stress hormones. The hormones stimulate catabolism, and more insulin is released. But because the insulin does not "unlock" the cells, the cells call for more energy, continuing the cycle with increased stress hormones, etc.