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Systemic response to surgical trauma

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٢٠٢١

الاهداء

الاهداء أولا لله سبحانه وتعالى الذي وفقني لإتمام هذا البحث

واهدي هذا المجهود البسيط الى والدي الذي كان وما زال مناره تضيء دروبي أينما رحلت.

واهديه لأمي الغالية التي علمتني وما زالت تعلمني ولم تبخل بالكلمة الصادقة نحوي حفظهما الله بمشيئته.

والى عائلتي التي كانت وما زالت سندي ومرجعي في الحياة داعية الله سبحانه ان يحفظهم من كل مكروه.

الشكر والتقدير

قال تعالى:

﴿اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ * خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ * اقْرَأْ وَرَبُّكَ الْأَكْرَمُ * الَّذِي عَلَّمَ بِالْقَلَمِ * عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ﴾

الشكر موصول لكلية الطب الموقرة واساتذتها المحترمين الذين لم يبخلوا بأي مجهود في ظل هذه الظروف الصعبة. واخص بالذكر الدكتور (احمد مظهر خلف) الذي لم يدخر جهدا في تعليمي وارشادي لإتمام هذا البحث بنصائحه وملاحظاته القيمة. والشكر موصول لكل من علمني ومهد طريق العلم الي.

Abstract

Trauma is a major clinical and surgical problem. It is very common , risky and costy condition that burden the health institutes around the world. There are many defense mechanism that the body adopts to protect the internal homeostasis during stress. There are alot of response mechanism which is complex and rapid in action include metabolic, nervous, circulatory, renal and immunological. We will try to emphasize in details the different responses their physiology and benefits and harms of them for the body.

Introduction

Trauma is the study of health issues that arise as a result of physical injury. An injury is the result of a physical force being applied to an individual. Thermal, ionizing, radiation, and chemical forces are just some of the forces that can cause injury (1). The word "trauma" comes from the Greek *trauma*, which means "wound." This word can be applied to both physical and psychological trauma (2).

However, the force involved in most injuries is mechanical. The subject of trauma therefore centers upon the deleterious effects of kinetic energy on the human frame. (1)

Trauma is a widespread, dangerous and costly public health problem. Terrorism, traumatic violence, negligence, death, disaster, war, and other emotionally distressing events all contribute to it. Trauma knows no bounds when it comes to age, gender, socioeconomic status, race, ethnicity, geography, or sexual orientation. It is almost universal among people with psychiatric and substance abuse problems. (3).

There are major and rapid physiological changes that occur during the trauma (or surgery); to maintain constancy of the internal environment *('milieu interieu'*) now termed homeostasis (4).

These include, a rapid adaptation of circulatory mechanisms to restore blood pressure and volume, activation of clotting mechanisms to reduce blood loss, the conservation of water and electrolytes by the kidneys and with the lungs maintenance of acid-base neutrality, the adaptations of the metabolic and immunological mechanisms which includes the mobilization of aminoacids from protein for gluconeogenesis and wound repair and the mobilization of fatty acids and glycerol from fat for energy production and gluconeogenesis respectively (5).

Afferent stimuli, such as altered circulatory volume and tissue injury, cause a neurohumoral response of stress hormones and cytokine production in response to surgical stress.

These have effects on the cardiovascular and metabolic processes. Type of surgery (70 percent), perioperative blood loss, and postoperative insulin resistance are the independent factors that predict length of hospital stay (6).

In this short article, we will demonstrate the systemic response to the Trauma from a clinical and surgical perspective.

The metabolic response to stress

Altered circulating blood volume

Volume depletion is the most important single factor that influences the systemic response to surgical trauma (7). Fluid loss is sometimes caused by hemorrhage, such as a ruptured abdominal aortic aneurysm, ectopic pregnancy, or damage to a major blood vessel. Extracellular fluid loss like, vomiting, as in intestinal obstruction, acute diarrhoea, and plasma loss, as in burns, are among the other triggers. During an acute hemorrhage, the hematological, cardiovascular, renal, and neuroendocrine systems are all stimulated (8).

Neuroendocrine response

As a result of decreased firing of baroreceptors from hypotension and decrease in sodium concentration, there is an increase in ADH from the posterior pituitary gland. ADH causes increased intravascular volume by reabsorption of NaCl and water at the distal tubule, collecting ducts and

loop of Henle. There is also an increase secretion of ACTH and Growth hormone directly through central autonomic pathways (8).

The sympathetic nervous system is stimulated by decreased baroreceptor activation (carotid sinus, aortic arch, Left atrium, pulmonary vessels) to increase noradrenaline release, which increases heart rate, myocardial contractility, and causes peripheral vasoconstriction (9).

Growth hormone has both catabolic and anabolic effects, but its increased secretion after surgery serves only a minor physiological function, and its diabetogenic effects aren't thought to be significant in the perioperative period. GH promotes glycogenolysis and lipolysis thereby inhibiting glucose uptake and consumption by cells. It can, however, play a more important role in preventing muscle protein breakdown and promoting tissue repair (23).

Renal response

The sympathetic nervous system stimulates renin secretion from the juxtaglomerular apparatus through decrease renal perfusion from renal artery vasoconstriction. The renin-angiotensin system is activated, Renin cleaves circulating angiotensinogen produced by the liver to angiotensin I, which is then converted to Angiotensin II by the lung and kidney (10).

Angiotensin II is not only a potent vasoconstrictor but also a powerful stimulator of aldosterone release from the adrenal cortex. Aldosterone, in turn leads to an increase in sodium reabsorption by the kidney. This coupled with the increase in free water retention induced by ADH leads to extracellular volume expansion (10).

The coagulation mechanism is activated, and contracting blood vessels release thromboxane (TxA). The activation of platelets causes an immature

blood clot to form on the bleeding source. Collagen is exposed in the damaged blood vessel, causing fibrin deposition and the development of a normal clot after 24 hours. (11).

Afferent nervous impulse

Pain is an important factor in the neuro-endocrine response to surgical trauma. The pain stimuli reach the hypothalamus and stimulate the autonomic nervous system and release of the pituitary hormones (12).

The patient had anticipated that pain would induce impulses from the higher centers prior to the injury. ACTH and GH levels rise within an hour of a laparotomy skin incision, paraplegics do not respond to operations below the level of cord transection in the same way, and spinal/epidural anaesthesia causes a delayed reaction (12).

The inflammatory response to the injury

The inflammatory cells from tissue damage release cytokines (interleukins IL1, 6) into the circulation which give an acute phase response (APR) (13). The acute phase response is a systemic response to localized tissue damage.

Systemic inflammatory response syndrome (SIRS)

The myriad of systemic effects include fever, leucocytosis, hypothalamic pituitary axis stimulation, immune activation and production of the acute phase proteins. The acute phase reactants are proteins mainly secreted by the liver during injury, unlike other tissues which undergo proteolysis during the metabolic response to injury (13).

The positive reactants (α chymotrypsin, complement C3, caeruloplasmin, fibrinogen, haptoglobin and C-reactive protein (CRP)) are those whose levels rise during the APR. The negative reactants (albumin,

transferring) levels decline during the same period. The acute phase reactants are part of the host-defence mechanisms to injury (14).

Adrenal response

There is a mutual relationship between glucocorticoids and cytokines. Cytokines are capable of stimulating the HPA axis during stress, and glucocorticoids facilitate the elaboration of the various acute phase proteins by the cytokines (15).

Glucocorticoids can also inhibit cytokine production. This paradoxical activity caused by the dual role played by glucocorticoids in a permissive fashion: initiates the host response and later as it remains elevated attenuate the homeostatic response (15).

Physiological effects of insulin during stress

Insulin is the most important anabolic hormone in the body. Insulin regulates glucose metabolism to keep glucose levels on very tight limits in healthy people (16).

The effect of insulin rises in all major stress situations, such as major surgery, due to the release of stress hormones such as glucagon, catecholamines, cortisol, and growth hormone, as well as the inflammatory response induced by cytokines. In response to stress, different tissues release amino acids, free fatty acids, and glucose into the bloodstream. The body's substrate metabolism shifts as well, and fat is eaten instead of glucose. Following procedures such as colorectal surgery, these reactions can be corrected with exogenous insulin therapy. The remaining metabolism has been stated to be normalized by infusing enough insulin to maintain glucose within normal range (17).

Stress-hyperglycemia and insulin resistance are extremely common, especially in critically ill patients with sepsis. Multiple pathogenic mechanisms are responsible for the metabolic response.(18)

In addition to the cortisol increase in stress response, epinephrine, norepinephrine, glucagon, and growth hormone also increase. Insulin levels are usually normal or decreased together with increased peripheral insulin resistance (because of increased activation of pancreatic alpha-receptors, insulin secretion is suppressed. In addition to insulin resistance, IL1 and TNF also suppress insulin secretion. Low or normal levels of insulin, and increase in other counter-regulatory hormones result in stress hyperglycemia (18, 19).

The factors affecting the systemic response

Severity of injury, the greater the injury the greater the response. Nature of injury, burns produce a greater response because of greater heat and fluid loss from the burn area (20). Infections potentiates the metabolic response. The catabolic phase persisting as long as infection remains. Other complications including DVT, pulmonary embolism and compartment syndrome potentiate the response.(20)

Ambient temperature modifies the response especially in burns where there is a reduced metabolic demand after injury if the ambient temperature is increased for example from 200C to 30-320C as there is decrease energy loss from evaporation of water (latent heat)(21).

Corticosteroids have a permissive role as mensioned above. A certain Age and sex has an influence as there is less metabolic response in children, women and the elderly.

Nutritional status: A well nourished patient withstands surgery better than one poorly nourished.

Anesthesia and drugs modify the response by affecting the vascular system and hormone production. Ether stimulates catecholamines and ADH, morphine stimulates ADH, spinal/epidural anesthesia decrease the initial response by blocking the afferent pathways (22).

The systemic response to surgery

The response is almost identical to the trauma except it is lesser in severity because of minimizing the infection risk and its concomitant Paralytic ileus after abdominal surgery (23).

During surgery, there are some countermeasures that can be used to reduce the systemic response. Anesthesia, which is known to influence some aspects of the stress response to surgery, is the most effective method. Opioids are believed to inhibit the release of hypothalamic and pituitary hormones. The hormonal reaction to pelvic and abdominal surgery is eliminated at high doses (fentanyl >50 mg kg1) (23, 24).

Anesthetic drugs such as Etomidate suppresses the production of corticosteroids in the adrenal cortex by reversible inhibition of the enzyme 11-b-hydroxylase and the cholesterol side chain cleavage enzyme. An induction dose (0.3 mg kg1) blocks the synthesis of aldosterone and cortisol for up to 8 h (24).

Benzodiazepines (midazolam 0.2–0.4 mg/ kg) and infusion of 0.9–0.125 mg/ kg/ h) may also have an inhibitory effect on steroid production at the hypothalamic–pituitary level, but the significance of this has not been established. Clonidine, a centrally acting anti-hypertensive, may decrease sympathoadrenal and cardiovascular responses to surgery (24).

The influence of regional anesthesia on the stress response has received a lot of attention. While cytokine responses are unaffected, epidural/spinal anesthesia can reduce glucose, ACTH, cortisol, GH, and

epinephrine changes. Excellent analgesia, reduced thromboembolic complications, increased pulmonary function, and reduced paralytic ileus are all essential benefits (24).

Other methods include the surgical technique; it may have some benefit in reducing the inflammatory responses. Cytokine release is reduced in less invasive surgery such as laparoscopic techniques leading to quicker recovery and discharge (8).

Nutrition can also play a major part in preventing the adverse effects of the stress response. Enteral feeding, in particular immunonutrition (glutamine, arginine, omega-3 fatty acids) has been shown to improve recovery (25).

There may also be a role for growth hormone and anabolic steroids in improving outcome. Insulin infusions, with and without glucose, may also reduce excess protein breakdown. Maintenance of normothermia is also beneficial in reducing the extent of the metabolic response to surgery (25).

Conclusion

The systemic response to stress (trauma, surgery and psychological stress) is well known and highly complex and morbid. Practicing some methods to decrease the response in trauma management and elective or emergency surgery found to enhance the total outcome and decrease the morbidity from overresponse.

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