Influence of Hormone Release during Acute Stress upon Plasma Glucose and Arterial Pressure

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SUMMARY. Stress is a common factor in daily routine, and yet little attention is given to the possible changes and disturbances caused by stress upon homeostasis. Therefore, this study aims to evaluate blood pressure (BP) and blood glucose (BG) before and after acute stress simulation and to verify the influence of catecholamine secretion upon these parameters. Acute stress simulation was achieved by submitting fifteen volunteers to a ride on a free-fall simulator at an amusement park. The distance of the fall is approximately 69.5 m and the velocity reaches 94 kph. BG was determined before and after the stress situation and BP was checked before and after that condition. The result demonstrated that the volunteers who had previously mentioned being afraid of the ride had a significant increase in BG immediately after stress and tended to have a higher BP, indicating that psychological factors, such as fear and anxiety, are related to significant changes in the parameters under evaluation.

INTRODUCTION

Defense mechanisms against stress stimuli involve sympathetic and hormonal responses, however, the influence of these responses upon other body activities should be better understood, specially, during the stressor event 1-3.

It is known that stress can have different influences on the human body, metabolism and hormonal responses. Stressor agents are potentially harmful, depending on environmental conditions and on individual characteristics 4,5.

Stress signifies the state generated by the perception of stimuli causing emotional arousal, and disrupting homeostasis, triggering a process of adaptation, among other changes, increase of epinephrine secretion, and production of different systemic manifestations, including physiological and psychological disorders 2.

Stress can be brought on by surgery and other invasive procedures, microorganisms penetration, pain, trauma, fear and other disturbances, which trigger different responses in the body in order to prepare or adapt it to the new conditions.

Hans Selye demonstrated 6, when exposed to an effort triggered by a stimulus (physical, chemical, biological or psychosocial) perceived as threatening to homeostasis, the body tends to respond uniformly, nonspecifically, and simultaneously anatomical and physiologically. This set of nonspecific reactions, in which the body participates as a whole, is known as the general adaptation syndrome. General adaptation syndrome comprises three phases: alarm reaction, resistance and exhaustion. The three phases do not necessary develop under a stressful situation and, only in the most serious cases is the last stage reached, that of exhaustion 4,7.

Alarm reaction is divided into two stages: shock and anti-shock. It has been reported that when an animal is subjected to threatening stimuli treble of homeostasis (fear, anger, hunger and pain), a reaction occurs to prepare the animal to fight or fly. There are different responses

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resulting from this reaction 8-10: a) increase in blood pressure and heart rate, allowing the blood to circulate more rapidly and transporting more oxygen and nutrients to the brain and skeletal muscles, facilitating mobility and movement; b) spleen contraction, offering more red blood cells to the blood stream, (more oxygen to the body particularly in strategically favored areas); c) blood glucose release (stored in the liver) to be used as food and, consequently, more energy for the muscles and brain; d) blood redistribution, reducing the flow to the skin and viscera and increasing the flow towards muscles and brain; e) respiratory rate increase and bronchi dilation, for the body to intake and receive more oxygen; f) pupil dilation and exophthalmos, that is, the protruberance of the eye out of the eyeball, to increase visual accuracy; g) increased blood lymphocytes, to repair possible damage to tissues by external aggressors.

These reactions are triggered by discharges of adrenergic marrow of the adrenal gland and norepinephrine in fibre post-ganglion of the autonomic nervous system. In addition, the axis hypothalamus-pituitary-adrenal is triggered, presenting a long-lasting and slow response, playing a crucial role in the adaptation of the body

Insulin is a hormone released by the pancreas when the plasma concentration of glucose increases and is detected by the β-cells. The main mechanism through which glucose stimulates the release of insulin requires the entry of the glucose into the beta cells by means of a glucose transporter related to the glucokinase which, in turns, phosphorylates the glucose and constitutes the essential sensor for insulin release. With the insulin in circulation, the tissue cells (dependent on insulin to capture glucose) present a change in the membrane, enabling glucose to be captured for the intracellular environment. Inside the cell, glucose undergoes chemical reactions turning into other compounds in order to generate energy to meet cellular needs 16.

Epinephrine, one of the existing types of catecholamines, is produced in the adrenal medulla, by autonomic neurons and is secreted by the nerve stimulation production on the adrenal glands during danger (real or imaginary), exercise, and exposure to low temperature hypoglycemia. To enable the reaction of a person to such situations, epinephrine causes a number of body changes, such as hepatic glycogenolysis, triacylglycerols of fat degradation, some smooth muscle relaxation (bronchi and arterioles) and increase in strength and heart rate. Epinephrine metabolic effects are catabolic, contrasting to
the effects caused by insulin and simultaneously acting as a coadjuvant with glucagon action, stimulating its release 7,15,17.

Actions that cause stress on the body also amend the bloodstream. After the release of catecholamines mediated by sympathetic hypothalamus stimulation and therefore the adrenal glands, neurotransmitters and hormones are discharged influencing the bloodstream, increasing blood pressure and causing vasodilatation/vasoconstriction in strategic areas, and may increase sweating, respiratory rate and cause bronchodilation, among other effects 2,12.

Therefore, the evaluation of blood glucose variation under situations of fear or stress is important. The objective of this study was to evaluate blood pressure and blood glucose before and after the simulation brought on by acute stress, caused by riding a free-fall simulator in an amusement park, and checking the influence of catecholamine release in these parameters.

MATERIAL AND METHODS

Patients

Fifteen healthy (self-declared) volunteers, from 18 to 26 years underwent an epinephrine discharge produced by falling from 69.5 m at 94 kph, at a free-falling simulator in an amusement park in Vinhedo – SP, Brazil. These patients were previously informed regarding the use of biological material to carry out the work and participated as volunteers.

Determinations

Blood glucose was determined in patients that fasted for 10 to 12 h (before the ride), immediately upon the end of the ride and at time intervals of 15, 30 and 60 min after being subjected to the acute stress caused by the ride. Blood glucose determination was carried out through digital puncture using Glicomiter (AccuChek, RocheTM, Brazil). Blood pressure was also determined for every volunteer before and after the ride using pressure meters.

Results Analysis

Figures were represented as mean ± standard deviation. The graphics were structured using Microsoft Excel software. Statistical analyses were performed with Sigmastat software, using the paired T-test (p <0.05).

RESULTS AND DISCUSSION

The average age of the volunteers was 22 ± 4 years and the time to queue before the ride was 90 ± 20 min. Of the volunteers who participated in this study, four were men and eleven women.

Fifteen volunteers were divided into two groups for a better interpretation of the results, for this purpose they were asked regarding their feelings about riding the free-fall simulator. After the responses the group was divided into: volunteers who claimed to feel fear (FEAR) and volunteers who claimed not to feel fear (WITHOUT fear).

Capillary blood glucose realization is influenced by the discomfort caused by the high number of nerve terminations in this region. Recent studies evaluated the accuracy of glucose meters by comparison to figures obtained by laboratory tests. The results obtained by glucose meters were therefore considered accurate 18.

Analyzing the overall outcome, considering all volunteers as a single group, there was no statistical difference - for either blood pressure (Fig. 1), or for blood glucose (Fig. 2) before and after the ride.

Figure 1. Mean and standard deviation values of arterial blood pressure, before and after the ride. For these measurements all volunteers were considered as a single group. The error bars represent 95% confidence limits for the measurements.

Figure 2. Mean and standard deviation values of blood glucose, before and after the ride. All volunteers were considered as a single group for these measurements. The error bars represent 95% confidence limits for the measurements.
Blood pressure values preceding and following the ride (Fig. 1) showed a mild increase in the systolic pressure of the volunteers after being submitted to the stressor event, which is explained as a result of the action of the autonomic nervous system which was strongly stimulated.\(^7,8\)

Figure 2 shows sudden blood glucose elevation determined immediately after the exiting ride. This result may be explained by the sympathetic nervous system reaction to a strong stimulation and thus enabling all the defense mechanisms that prepare the body to confront any possible danger. The activation of several metabolic pathways triggers many reactions and have been stalled for generating only glucose to provide the energy needed for the body.\(^8,13,19\)

As the event stressor reached a peak and then stopped, blood glucose values were lower in the subsequent minutes. However, they increased again from 30th min on, which can be explained by stress-released epinephrine acting concomitantly with basal epinephrine. This last action is long lasting and, can therefore continue to stimulate the metabolic pathways to produce glucose even after the stress stimulation stops.\(^8\)

When the total group of subjects was separated into two new groups denominated FEAR and WITHOUT fear and were analyzed individually, the blood pressure results, though not statistically significant, were incongruent. The observed changes could be considered statistically significant if the numbers of volunteers (n) were higher.

Figure 3 shows the average and standard deviation of the blood pressure value, before and after the ride departure for the members of the FEAR group. Each member of this group individually had a tendency to an increase in systolic blood pressure, after the ride. There was a subtle increase in systolic pressure of the FEAR group, whereas there was a small decline in the diastolic value showed. The outcome of the participants of the WITHOUT fear group (Fig. 4) proved to be reversed, that is, there was a small reduction in systolic pressure with a mild increase in diastolic pressure.

The trend to increased blood pressure during the catecholamine abundant release (and other hormones released in a state of acute stress) can be explained as part of the preparation of the body known as the “fight and flight” reactions. The epinephrine and norepinephrine, released by the adrenal medulla under the sympathetic stimulation, activated by fear and anxiety caused by the free-fall in high-speed, promoted the increase of the index of heart contraction strength, increasing blood pressure and hyperventilation.\(^7,8,19\). It explains the fact that the systolic and diastolic pressures have shown greater results after the exiting ride.

Figure 5 shows average and standard deviation of the blood glucose results of the FEAR group and Figure 6, the average standard devia-
tion of blood glucose of the WITHOUT fear group.

The value found in the blood glucose measurements of the FEAR group - immediately after excitation - was statistically significant (p < 0.05), there was a great exacerbation of the effects on those individuals who were afraid of the ride. One can assume that not only physiological factors, such as the inadvertent activation of the sympathetic nervous system, during the fall at high speed are involved. Other psychological factors also play important roles in the outcome of that group, such as mental stress, which is crucial for the type of central nervous sysreaction, as there is strong participation of the amygdala, which is the region of the brain responsible for responses to fear, anxiety, panic and other types of mental stress 11.

During acute stress, the hypothalamus generates signals that are propagated by the sympathetic nerves through the spinal cord. These signals reach the adrenal medulla activating it and releasing epinephrine and norepinephrine. When a large quantity of catecholamines is in the circulation, there is an increase in the metabolic rate, the glycogenolysis, and the release of glucose and free fatty acids in the blood. They also act upon the fat tissue, stimulating lipolysis, increasing the production of glycerol and releasing it into circulation. A greater concentration of glycerol stimulates gluconeogenesis in the liver the, which increases the production of glucose. As a result, there is an increase in the glucose concentration and greater glycogen mobilization in response to the stressor agent 19,20.

Pancreatic cells are stimulated by low concentrations of blood glucose and sympathetically by α-receivers and as a result, there is glucagon release. Among the reactions to glucagon in the liver there are glycogenolysis and gluconeogenesis, increasing the concentration of glucose in the blood 13,19.

Low concentrations of the glucagon also act on fat, increasing lipolysis, which maintains glycerol available for a longer period for gluconeogenesis in the liver. Glucagon increases the transport of glycogenic amino acids into the liver, providing more substrate for gluconeogenesis 13,20.

In addition to catecholamines and glucagon there is a third hormone that acts in the same direction, cortisol, which is also released in stress situations (although its performance is more significant in chronic stress conditions). Cortisol decreases the glucose uptake and absorption by the muscle, and also increases the protein catabolism to provide substrate for gluconeogenesis, and facilitates the glucagon action. This hormone is produced in the cortex of the adrenal glands and is released into circulation by sympathetic stimulation from the hypothalamus under stress 16.

The conditions described above increase the glucose plasma concentration before a stimulus, providing energy to the brain, heart and muscles, preparing the body to react 5,8,21.

Both groups in this study presented increased blood glucose from the 30th minutes on after riding the free-fall simulator. This fact can be explained by the action of norepinephrine, a catecholamine released over a longer period of time on acute stress.

Epinephrine, when in the blood, is effective for about 2 min, however, the norepinephrine can remain active for up to several hours, producing a prolonged action in relation to epinephrine. This may explain the elevation of the results of blood glucose up to the 60th minutes, as the norepinephrine could still be acting upon the metabolism 19.

The catecholamine released during this stressor event could be measured and monitored in plasma and urine, providing interesting data to better assess the concentration of glucose, catecholamines and blood pressure correlation, however the methodology used for that purpose could not be executed in the place with the available resources 15.

CONCLUSION

From the results of this study one may infer that not only the stress hormones released under excitation are capable of changing the homeostasis as determined by blood pressure and blood glucose levels. Psychological factors
such as anxiety and fear can also cause significant variations in blood glucose and blood pressure, as the increase of nerve stimulation in centers associated with these feelings also strongly activate the metabolic pathways related to these activities.

REFERENCES