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Using blood glucose estimation to interpret stress in patients undergoing minor oral surgery procedures

Abstract

Purpose: A prospective randomised case control study was conducted to evaluate the stress induced in patients during minor oral surgical procedures based on the variations in blood glucose levels, blood pressure and pulse rate and thereby to assess the relation between stress and the aforesaid parameters.

Materials and methods: A total of 100 subjects who required routine minor oral surgical procedures were randomly divided into two equal groups with subjects of test Group I receiving 2 % lignocaine with adrenaline, subjects of control Group II received the same with an added oral intake of 10 mg glucose in 200 ml water after administration of local anaesthesia. The blood glucose level, blood pressure, and pulse rate were recorded before the commencement of procedure with the patient on the chair, before and immediately after local anaesthetic administration, finally after the procedure, and the obtained data was statistically analysed.

Results: The blood glucose levels were found to decline at a point before extraction and then increase to a value higher than the preoperative value in group I, while in groups II the blood sugar values maintain a steady state without decline, until it progressively increases to a higher post-operative value. In all groups blood pressure was found to elevate progressively and an increase in pulse rate was observed in all stages till the administration of LA after which there was a marked decline.

Conclusion: Our results point towards the phenomenon of a short lasting decline in blood glucose levels for a period of not more than four or five minutes before an elevation in blood glucose levels. In minor oral surgical procedures under local anaesthesia, this momentary hypoglycaemia is of great clinical significance as even moderate hypoglycaemia can lead to episodes of psychogenic syncope.

Keywords: stress, hypoglycaemia, blood glucose, stress response

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Introduction

Stress response is defined as the hormonal and metabolic changes that accompany injury and trauma and encompasses a variety of endocrinological, immunological and haematological events. It is defined as a state of disharmony or disturbances in homeostasis provoked by psychological, environmental or physiological stressor situations.[1,2] These situations promote immunoinflammatory and metabolic responses that are entangled in an intricate way, as the cells involved in these key events ontogenetically originate from a unique primordial organ combining both immune and metabolic functions.[3–12] In 1932 Cubberston documented and quantified the time course of stress response and introduced the terms "ebb" and "flow" to describe an initial decrease and subsequent increase in metabolic activity due to stress.[1] After the early work on stress response to accidental injury, attention turned to surgical trauma and responses to most types of surgery were reported. Following this, the ability of anaesthetic agents and neural blockade to modify stress responses has been studied. Although it seems that the stress response developed to allow injured animals to survive by catabolising their own body fuels, it has been argued that the response is unnecessary in current clinical practise (Figure1).[1-10]

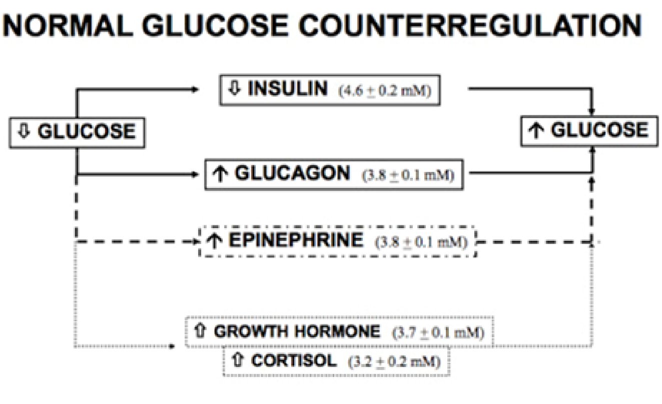


Figure 1 Flow chart of Normal glucose counterregulation.

When a situation is interpreted as being stressful, it triggers the activation of the hypothalamic-pituitary-adrenal (HPA) axis whereby neurons in hypothalamus release a hormone called corticotrpin-releasing-hormone (CRH).[4] This triggers the pituitary gland to secrete adrenocorticotropin (ACTH) which acts on adrenal glands to secrete cortisol. In parallel, the stress response involves hypothalamic stimulation of sympathetic nervous system resulting in secretion of catecholamines from adrenal medulla. In addition there is release of growth hormone and prolactin. The circulating catecholamines, cortisol and growth hormone result in elevated blood glucose levels. Consequently, synthesis and release of insulin is stimulated to maintain blood glucose levels within normal range.[1-13] In the pancreas glucagon is released and insulin secretion may be diminished. The overall metabolic effect of hormonal changes is increased catabolism that mobilizes substrates to provide energy sources and a mechanism to retain salt and water and maintain fluid volume and cardiovascular homeostasis.[2–16]

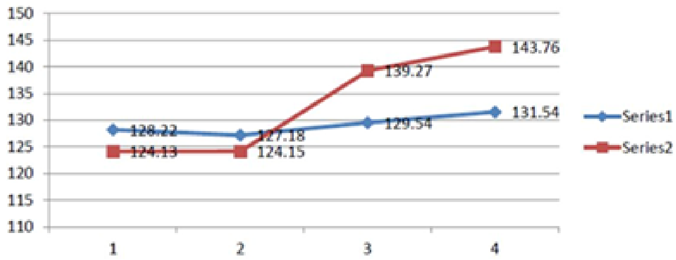
The net effect of endocrine response to stress as a result of surgery is an increased secretion of catabolic hormones. Blood glucose concentrations increase after surgery begins. Cortisol and catecholamines facilitate glucose production as a result of increased hepatic glycogenolysis and gluconeogenesis. In addition peripheral glucose consumption is decreased. Blood glucose concentrations are related to the intensity of the surgical injury and the changes are less marked in minor surgeries.[1–20] Although hyperglycaemia is a feature in acute stress, this effect is reversed in the initial phase of stress. It is known that subjects with greater stress experience show less hyperglycaemic response to adrenaline injection. The fall in blood sugar might be the direct consequence of a psychogenic stimulus. The parasympathetic nervous system, acting through the vagus, is known to induce insulin release and thus cause hypoglycaemia.[5–19]

Materials and methods

A randomised, prospective, case-control study was done in the Department of Oral and Maxillofacial Surgery, Meenakshi Ammal Dental College, Chennai, over a period of nine months from November 2014 to September 2015 after obtaining IRB clearance and informed consent from the concerned patients. All patients undergoing minor oral surgical procedures like therapeutic extractions, Tran's alveolar extractions including impactions, and alveoloplasty, without any underlying systemic conditions that contraindicated the procedure and willing to participate in the study were included. Subjects with systemic diseases except diabetes mellitus and hypertension, subjects on steroid therapy three months before undergoing the study, pregnant and lactating mothers and subjects with intolerance or adverse reaction to local anaesthetics or nonspecific drugs were excluded from the studies. Hundred patients who required routine minor oral surgical procedures and fulfilled the inclusion criteria for the study were selected after obtaining written informed consent. Patients were randomly divided into two groups. In test group patients' blood pressure, pulse rate and blood glucose were recorded on chair, before local anaesthesia administration, after local anaesthesia administration, and after completion of procedure, simultaneously noting the time difference between each step. In control group, 10 milligram of glucose in 200 ml of water was given after administration of LA to all the patients and same parameters were recorded. All the patients' blood pressure, pulse rate and blood glucose were recorded on chair, before local anaesthesia administration, after local anaesthesia administration, and after completion of procedure, simultaneously noting the time difference between each step. Data was collected and analysed for statistically significant correlations. Blood glucose was measured by the following protocol -After disinfection with an alcohol swab, one of the fingers was prepared and pricked with a disposable lancet to draw blood. The drop of blood was then added to the test strip (Accucheck one touch test strip) and readings noted from the glucometer. Pulse and blood pressure was measured using digital blood pressure monitor. All the data collected were analysed for statistically significant correlations.

Results

100 subjects were randomly divided into two groups, test group I and control group II. Group I consisted of 68% female 32% male patients with an average age of 36.6 years, and group II consisted of 54% male patients and 46% female patients with an average age of 31.4 years. 40% of the subjects under study had a history of dental extractions within the past 4 years. The blood glucose levels were found to decline at a point before extraction and then progressively increase to a value higher than the preoperative value in the group I. In group II, the blood sugar values maintain a steady state without decline and progressively increase to a higher post-operative value (Graph 1). In test group I, the range of blood glucose level on chair varied from a highest value 186 mg/dl to a lowest of 77 mg/dl with a mean of 128.22mg/dl, while the blood glucose level after administration of LA ranged from a peak value of 185 mg/dl to a lowest of 79 mg/dl with a mean of 127.18. The blood glucose level in group I before extraction demonstrated the range of values from 186 md/dl to 72 mg/dl with a mean of 129.54 and the final evaluation of blood glucose levels immediately post extraction revealed a range of values from a highest of 186 mg/dl to a lowest of 78 mg/dl with a mean of 131.54 mg/dl.



Graph 1 Variation in average blood glucose levels in groups I and II.

In control group II, the range of blood glucose level on chair varied from a highest value 182 mg/dl to a lowest of 76 mg/dl with a mean of 124.13mg/dl, while the blood glucose level after administration of LA ranged from a peak value of 185 mg/dl to a lowest of 81 mg/dl with a mean of 130.05 mg/dl The blood glucose level in group II before extraction demonstrated the range of values from 186 md/dl to 84 mg/dl with a mean of 139.27 mg/dl and the final evaluation of blood glucose levels immediately post extraction revealed a range of values from a highest of 191 mg/dl to a lowest of 89 mg/dl with a mean of 143.76 mg/dl. Analysis of variation in capillary blood glucose levels in patients with a history of previous extractions and patients with no history of previous extraction revealed that the decline in blood glucose levels in patients undergoing first time dental extraction to be noticeably higher than experienced patients (Graph 2). Pulse rate and blood pressure showed progressive increase during the procedures in all patients. Average pulse rate and blood pressure are depicted in Graphs 3&4 respectively. Pulse rate was observed to increase till stage three of the procedures and then decline to a value higher than the preoperative value.

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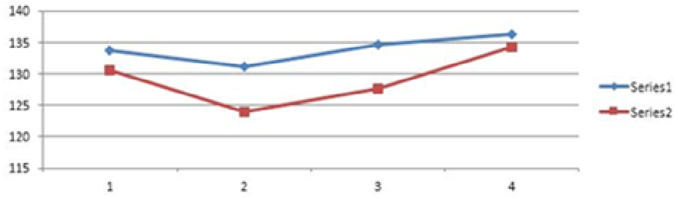
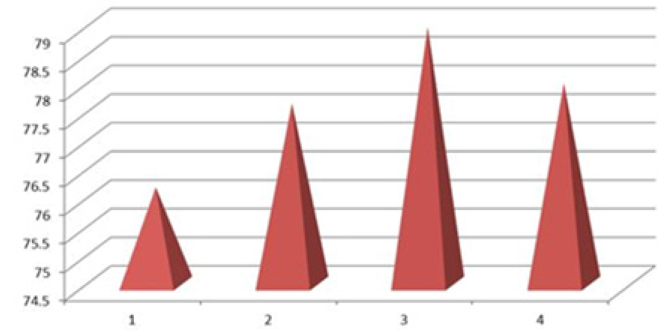
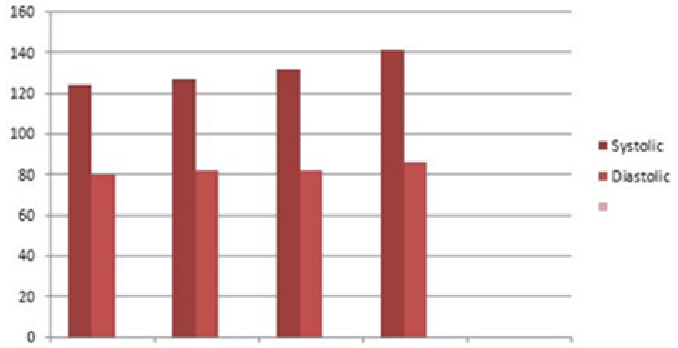


Graph 2 Variation in capillary blood glucose levels in patients with a history of extraction versus patients undergoing first time extractions.



Graph 3 Variation in pulse rate in all subjects.



Graph 4 Variation in blood pressure in all subjects.

Discussion

The term "stress" is widely used in relation to distress resulting from psychological, environmental, or physiologic conditions, the measurement of which is difficult to establish because perception and manifestation of stress is subjective and multifactorial. The stress response to surgery is characterised by increased secretion of pituitary hormones and activation of sympathetic nervous system, which have secondary effects on target organs like adrenal glands, leading to a cascade of hormone secretions.[1–20] During stress response, hypothalamic activation of the sympathetic autonomic nervous system results in increased secretion of catecholamines from adrenal medulla and release of norepinephrine from presynaptic nerve terminals. Increased sympathetic activity results in cardiovascular effects of tachycardia and hypertension.[1–22] Surgery is one of the most potent activators of ACTH and cortisol secretion with increase in plasma concentration within minutes of the commencement of surgery, increasing to a maximum within 4-6 hours after that depending on severity of surgical trauma. Metabolic effects of cortisol lead to protein catabolism, gluconeogenesis and inhibition of glucose uptake by peripheral cells leading to increased blood glucose concentrations.[1–23] There has been a great deal of interest in the modification of the stress response with respect to the potential beneficial effects on surgical outcome. The extent to which the responses are modified depends on the choice of the analgesic techniques used. Inhibition of stress responses is greatest with neural blockade with local anaesthetics. Therefore attention has focused largely on the effects of regional anaesthetic and analgesic regimens, particularly epidural blockade with local anaesthetic agents. Individual studies show that provision of analgesia using neural blockade leads to improvements in physiological variables in specific organ systems. The stress response to surgery comprises a number of hormonal changes initiated by neuronal activation of the hypothalamic-pituitary-adrenal axis. The overall metabolic effect is one of catabolism of stored body fuels. In general, the magnitude and duration of the response are proportional to the surgical injury and the development of complications such as sepsis.[1–27] In our study we have made use of blood glucose as a primary parameter and blood pressure and pulse rate as adjuvant parameters to quantify and evaluate stress in patients undergoing minor oral surgical procedures. The blood glucose levels were found to decline at a point before extraction and then progressively increase to a value higher than the preoperative value in the group I, but in group II the blood sugar values maintain a steady state without decline and progressively increase to a higher postoperative value. In the present study, we have also found a higher degree of fall in glucose levels in patients with no history of previous extractions than in patients who had undergone previous extractions, indicating a greater stress response to minor oral surgical procedures the first time, which is in line with previous studies. This may be attributed to the conditioned response to dental treatment and decreased anxiety levels in experienced patients. In a few select patients, who showed a marked decline in glucose levels even with a history of extractions, the causative factor can be attributed to previous traumatic dental treatment experience that elevates anxiety levels. Paul C Salins et al.[2] did a prospective study in which glucose level was estimated in capillary blood of 16 patients, who had vasovagal syncope during exodontia with local anaesthesia. One consistent finding was the low blood sugar level in all patients during syncope, as compared with the level 1 hour after recovery. The proposed hypothesis by the authors is that blood glucose levels lower than 2.2mmol/litre causes neutroglycopenia, symptoms of which stem from cerebral dysfunction caused by lack of glucose for maintenance of intracellular metabolism. This coupled with hypotension and hypercapnoea (especially in case of patients with poor nutrition or fasting patients, can lead to syncope. Losser et al.[12] did a retrospective study to determine role of glucose levels in stress conditions in ICU and concluded that glucose metabolism is profoundly altered in acute conditions and stress induced hyperglycaemia is an adaptive response to stress with altered glucose metabolism resulting in redistribution of glucose consumption towards other metabolic pathways such as lactate production. Jason Radley et al.[13] in a review of stress risk factors and pathophysiology found that physiological stress responses are initiated rapidly and are designed to optimize mobilization of resources and restoration of homeostasis of the sympathoadrenomedullary system occurs within seconds of perceived stress. Sympathetic nervous system (SNS) excitation promotes norepinephrine-induced changes in numerous bodily systems, including increases in heart rate and blood pressure, and causes adrenomedullary epinephrine release, promoting hepatic glycogenolysis. The hypothalamo-pituitary-adrenocortical (HPA) axis response is initiated on a slightly longer time scale (due to its neuroendocrine components). The HPA axis introduces glucocorticoid hormones into the circulation to provide further redistribution of energy resources (e.g., hepatic gluconeogenesis), while also serving to limit the duration and impact of the initial stress response.[13–26] The findings are consistent with the results of our study, that blood pressure and heart rate increases progressively in stress conditions in both study groups.[13] Since it is evident that HPA axis response which causes cortisol release and sequalae of increased blood glucose level is a delayed response and initial sympathetic nervous system response causes release of norepinephrine causes peripheral uptake of glucose and thus resultant temporary lowering of glucose levels in groups I and II and group II exhibits no decline because of additional supplementation of glucose.[19–25]

Conclusion

Over the years, many studies have attempted to evaluate the relationship between stress response and blood glucose levels in conditions of surgical trauma and although the type of stress and protocols of measurement of parameters were varied, a majority of studies came to the conclusion and established that blood glucose levels elevate over time in response to stress. In our study we have found this to be true to some extend but our results point towards the phenomenon of a short lasting decline in blood glucose levels for a period of not more than four or five minutes before going for a progressive elevation in blood glucose levels. This variation may not be very relevant in major surgical procedures under general anaesthesia, but in minor oral surgical procedures under local anaesthesia, this momentary hypoglycaemia is of great clinical significance as even moderate hypoglycaemia can lead to episodes of psychogenic syncope. This variation is of further importance in patients of poor nutrition or patients on fasting in whom studies have already established prevalence of higher rates of aerobic metabolism with reduced respiratory gas exchange, which, combined with an already depleted supply of readily available substrates can lead to added deteriorative effects.

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Conflicts of interest

Author declares that there is no conflict of interest.

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