Comparative Study of Children's' Blood Sugar in Fluid Therapy with Dextrose Saline, Ringer and Normal Saline 9.0% Serums and its Relationship with Depth of Anesthesia in Elective Surgery

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Research Article

Keywords: Anesthesia, Blood sugar, Child, BIS, Elective Surgery, Ringer Serum, Dextrose Saline Serum, Normal Saline 0.9%.

Posted Date: January 5th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-129047/v1

Abstract

Background: This study was aimed to determine the children's' blood sugar level in fluid therapy with DSS, RSand NS 0.9% serums and its relationship with the depth of anesthesia in elective surgery.

Method: This double-blind experimental study was performed with 90 children referred to the surgical ward, including: group A (receiving DSS), group B (receiving NS 0.9%) and group C (receiving RS) that the blood sugar of each group in 5 steps was measured: half an hour before induction of anesthesia, during induction of anesthesia, half and one hour after induction of anesthesia and after complete awakening in recovery. In addition, the monitoring the vital signs, measuring depth of anesthesia, pulse oximetry and electrocardiogram were performed for all groups.

Results: The results showed that the mean blood sugar in the 5 steps measured had a significant difference in three groups under study ($P < 0.05$). The mean blood sugar in the group receiving DSS was significantly higher than the two groups receiving RS and NS 0.9%. Also the mean depth of anesthesia in three groups did not show a significant difference.

Conclusion: Finally, according to this study, the use of DSS from the beginning of anesthesia, RS half an hour after the start of anesthesia and NS 0.9% one hour after the start of anesthesia can increase blood sugar in children. Therefore, the use of DSS is not recommended due to the stressful nature of anesthesia and operating room and the possibility of hyperglycemia.

Background

In the development of modern anesthesia and surgery, creating a safe outcome for the patient is one of the main factors. Over the past two decades, mortality and morbidity have declined significantly due to increasing pathophysiological knowledge, optimization of the disease process, use of safer and newer drugs, continuous monitoring and preoperative control, and postoperative care. Recognition of physiological changes caused by surgery and anesthesia is one of the most important medical advances in recent years (1). These changes directly affect the cardiovascular system, metabolic, fluid, and electrolyte of the body and lead to increase the risk to the patient (2). Also, certain metabolic and hormonal changes occur in all surgeries, which are mainly due to stimulation of the sympathoadrenal system and are catabolic in nature (3). Despite a variety of preoperative and surgical stimuli, the body's response to an invasion has components in common (4).

Surgical stress responses can lead to insulin deficiency and increase insulin resistance, eventually lead to decreased insulin secretion and increased blood sugar level (2). Improving postoperative blood sugar control (plasma glucose level 80–110 mg /dl) using continuous intravenous (IV) insulin injection significantly leads to reduce mortality in patients with postoperative intensive cares and mechanical ventilation after hard surgery (5). Hyperglycemia is a major metabolic response to stress and trauma that is associated with increased circulating epinephrine and glucagon and causes to increase hepatic glucose production (6). Some recent studies have shown an association between hyperglycemia and increased postoperative mortality in children (7). Symptoms of changes in blood sugar are hidden under general anesthesia, which these changes can cause morbidities for the patient, such as hyperglycemia, which can prevent proper surgical wound healing and increase the incidence of site infection, as well as reduce neutrophil chemotaxis and disrupt phagocytic activity and worsen neurological problems in the event of cerebral ischemia (8).

On the other hand, there is a possibility of hypoglycemia before or after anesthesia due to the need for preparations before elective surgery or in other words, being an NPO and the presence of surgical stress and the response of each person's body in a way that causes to stimulate the body's defenses (6). Preoperative fasting may lead to decrease glucose and lactic acidosis level. The brain needs a constant supply of glucose for providing energy. Therefore, it is important to maintain glucose level within the normal range to ensure proper brain function (9). Rapid glucose reduction occurs in some patients as confusion, change in state of consciousness, and blurred vision (10). *Glass et.al* reported that the EEG[1] of the brain in the insulin-induced hypoglycemic state was similar to state of general anesthesia (11). Also, the use of general anesthetics such as narcotics and sodium thiopental can weaken the response to surgical stress and cause hypoglycemia (8). For this purpose, *Manafi et.al* conducted a study entitled "*comparing blood sugar changes in spinal anesthesia with general anesthesia in cesarean section*", which the results showed that local anesthesia caused hypoglycemia and reduced postoperative complications compared to general anesthesia using a combination of intravenous and inhaled anesthetics in cesarean section (12).

Following any type of stress, including induction and maintenance of anesthesia and the surgical process, the interaction of different hormones effect (decrease in insulin versus increase in glucagon, catecholamines, cortisol and growth hormone) interferes with blood sugar control during surgery (13, 14). For example, in one study, injecting 5% dextrose serum during anesthesia caused a significant increase in blood glucose after the infusion, while giving NS in the group under comparison did not show any significant change in the patient's blood sugar level (15). Also, glucose-containing fluids, which are consumed before operation, have been caused to reduce postoperative insulin resistance in some studies (16). Therefore, in the fluid therapy that begins in the operating room before anesthesia, dextrose-free fluids are used and in most centers, injected fluids during anesthesia include NS and RSs (17). Also, *Jannat Makan et.al* in their study showed that the presence of dextrose-containing fluids is not necessary for fluid therapy during elective surgery and only monitoring blood sugar during long-term surgeries is recommended to prevent hypoglycemia and its complications (18).

In this regard, *Pereira et.al* in a study aimed at identifying risk factors for postoperative hyperglycemia, showed that hyperglycemia occurs severely in the recovery and factors such as age, BMI[2], corticosteroids, blood pressure and fluids received during the operation play an important role in this increase (19). Regarding that changes in blood sugar affect brain metabolism and its function, evaluation of brain function during anesthesia has been considered as a monitoring method and based on this, parameters such as *Bispectral Index, Audiutory Evoked Potential Index and Patient State Index* were evaluated (20-23). What is certain is that electroencephalogram waves are affected by anesthesia and brain metabolism. Different patterns of these waves are seen during different stages of anesthesia. These waves can be used as processed or unprocessed or raw. The use of raw form is difficult because it is very complex and influenced by artifacts, and its interpretation requires the presence of an experienced person (24). This device introduces a small computer using these indicator waves, which is known as BIS[3]. This index has already been used to measure the depth of anesthesia (25, 26).

Therefore, hiding the symptoms of changes in blood sugar during surgery in case of hypoglycemia or hyperglycemia raises the need for brain monitoring and measurement of blood sugar in surgeries, and considering the irreversible complications of hypoglycemia or hyperglycemia and the lack of specific symptoms in children under anesthesia, it seems necessary to pay attention to these two cases. Therefore, we decided to study the effect of the relationship between the depth of anesthesia and children's blood sugar levels before, during and after anesthesia in conventional fluid therapy, NS and ringer in elective surgeries of children.

Footnote:

[1] EEG: Electrocardiography

[2] BMI: body mass index

[3] BIS: Bispectral Index Monitoring

Methods

Researchers confirm that all methods were carried out in accordance with relevant guidelines and regulations. Following the local ethics committee's approval (Ethics Committee of Dezful Medical School, Iran, No. IR.DUMS.REC.1396.32 dated January 2, 2018).

This double-blind experimental study with study population includes 90 children referred to big hospital of Dezful in order to do elective surgeries. Inclination criteria to the study included age group 3-10 years, ASA[4] class 1 and 2, NPO duration of 8 hours and exclusion criteria including duration of surgery less than one hour, the presence of underlying disease (kidney, liver, diabetes, respiratory, heart and thyroid), any sharp rise or fall in the baby's blood sugar at any time during the study that requires invasive treatment, and steroid use 72 hours before anesthesia.

According to the inclination criteria, patients were randomly divided into three groups of 30 persons through a table of random numbers, which the first group (A) received DSS (5% dextrose serum in 0.9% sodium chloride), the second group (B) received NS 0.9% (intervention group 1) and the third group (C) received RS (intervention group 2). In this study, all persons underwent general anesthesia, and they were received thiopental sodium (3-5 mg / kg), fentanyl (1-3 micrograms per kg), midazolam (0.1-0.3 mg / kg), atraconium (0.3-0.5 mg / kg) and N_2O 50% and O_2 50% for anesthesia.

In addition, the patient's body temperature was kept constant at 36.5 to 37.5 ° C in all stages of the surgery using a mercury thermometer in the armpit. A blanket or warmer was used to prevent the baby's body from getting cold.

In each of these three groups, patients' blood sugar was measured in five stages including half an hour before induction of anesthesia, during induction of anesthesia, half an hour after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery using the glucometer. It should be noted that for all study groups, vital signs monitoring was conducted including: respiration rate, heart rate, systolic and diastolic blood pressure, pulse oximetry, electrocardiogram, as well as monitoring the depth of anesthesia.

Data collection tools

The tools used in this study include:

Selection form of groups under study: This form was designed based on inclination and exclusion criteria, which was completed by interviewing the patient's parents and reviewing the patient file.

Personal information form: This form contained questions about the patient's personal information and records, which were completed by interviewing the parents and reviewing the patient's file.

Vital signs assessment form: This form contained the patient's vital signs which included: HR[5], BP[6], T[7], RR[8], BIS and BS[9] and was measured in 5 steps including: half an hour before induction of anesthesia, during induction of anesthesia, half hour and one hour after induction anesthesia and during complete awakening of the child in recovery.

BIS device (Bispectral Index): This device measures the patient's awakening and awareness during surgery, which is based on dividing the numbers that exist in this device so that: values 85-100 were considered equivalent to awake, values 65-85 equivalent to sedation, 40-65 equivalent to general anesthesia, 30 to 40 equivalent to deep hypnosis, and 0-30 equivalent to burst suppression. The device intended for this purpose was the *American type called BIS VISTA*, which was made by *AS PECT MEDICAL USA*.

Glucometer device: The patient's blood sugar was measured through this device. This device is made in the USA with the brand of *Equio Glucometer Check Proforma* made in America, which was calibrated by the medical engineer of the hospital.

After data collection, the forms were coded and entered into the computer. After ensuring the accuracy of data entry, data analysis was performed by SPSS software and the following statistical methods were used. First, the normality of quantitative variables was determined by Kolmogorov-Smirnov tests. Descriptive statistics including indices of central tendency and dispersion (mean and standard deviation) and frequency distribution were used to describe the characteristics of the study groups. Kruskal-Wallis test was used to compare the variables of vital signs, BS and BIS and analytical test of GEE was used to evaluate the effect of repeated variables according to groups under study A, B and C in 5 stages: half an hour before induction of anesthesia, during induction of anesthesia, half an hour after induction of anesthesia, one hour after induction of anesthesia and during awakening of the child in recovery, and a significance level was considered less than 0.05.

Footnote:

[4] ASA: American Society of Anesthesiologists

[5] HR: Heart rate

[6] BP: Blood Pressure

[7] T: Temperature

[8] RR: Respiratory Rate

[9] BS: Blood Sugar

Results

The results showed that there was a significant difference between the three groups in terms of demographic characteristics, age and weight of children before the study, and the groups were not identical in terms of these variables (P <0.05). However, there was no significant difference between the three groups before the study in terms of variables of gender, level of education, classification of patients' physical condition according to the *American Society of Anesthesiologists* (ASA) and history of surgery, and the groups were similar in terms of these variables (05/0 0 <P). Table 1 shows the details of the demographic and clinical characteristics of children.

The results of this study indicated that in general, respiration rate (P-value <0.001), heart rate (P-value = 0.004), systolic blood pressure (P-value <0.001), diastolic blood pressure (P-value < 0.001), arterial oxygen saturation rate (P-value <0.001), BIS (P-value <0.001) and blood sugar level (P-value <0.001) showed statistically significant differences during repeated time measurements.

The results of *Kruskal-Wallis* test show that the respiration rate 30 minutes before surgery, during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction, after complete awakening of the child in recovery was not statistically significant between the three groups. However, the mean respiration rate during induction of anesthesia and one hour after induction of anesthesia showed a statistically significant difference between the three groups under study (Table -2).

The results of GEE test showed that the mean respiration rate in the N / S 0.9% serum group had significant decrease in time points during induction of anesthesia, 30 minutes after induction of anesthesia and one hour after induction of anesthesia compared to baseline condition. In the DSS group, a significant decrease in the mean respiration rate was observed at time points during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery compared to baseline condition. In the RS group, no significant decrease in the mean respiration rate was observed compared to the baseline condition (Table -2).

The results of one-way variance analysis and Kruskal-Wallis test show that the mean heart rate, 30 minutes before surgery, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after full awakening of the child in recovery did not have statistically significant difference according to the three groups under study. However, the mean heart rate during induction of anesthesia showed a statistically significant difference between the three groups under study (Table 3). The results of GEE test showed that the mean heart rate in the N / S 0.9% serum group at time points of one hour after induction of anesthesia and after full awakening of the child in recovery and in the sugar-saline group at time point during induction of anesthesia had a significant increase compared to the baseline group. However, in the RS group, no changes were observed in the mean heart rate compared to baseline condition (Table 3).

The results of Kruskal-Wallis test show that the mean systolic blood pressure during induction of anesthesia and 30 minutes after induction of anesthesia was not statistically significant between the three groups. However, the mean systolic blood pressure 30 minutes before surgery, one hour after induction of anesthesia and after complete awakening of the child in recovery showed a statistically significant difference between the three groups under study (Table 4). The results of GEE test showed that the mean systolic blood pressure in the N / S 0.9% serum group had a significant increase in time points during induction of anesthesia, 30 minutes after induction of anesthesia and after complete awakening of the child in recovery from baseline condition. In the sugar-saline serum group, a significant increase in mean systolic blood pressure was observed at all time-points (during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery) compared to baseline condition. In RS group, a significant increase in mean systolic blood pressure was observed only at the time point after complete awakening of the child in recovery compared to baseline condition, (Table 4).

The results of Kruskal-Wallis test show that the mean diastolic blood pressure at all time-points including: 30 minutes before surgery, during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery had no statistically significant difference according to three groups under study (Table-5). The results of GEE test showed that the mean diastolic blood pressure in the N / S 0.9% serum group and the DSS group increased significantly at all time-points (during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery) relative to baseline condition. However, in the RS group, no changes were observed in the mean diastolic blood pressure compared to baseline condition (Table 5).

The results of Kruskal-Wallis test show that the mean arterial oxygen saturation rate at all time-points including: 30 minutes before surgery, during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery had no statistically significant difference according to three groups under study (Table-6). The results of GEE test showed that the mean arterial oxygen saturation rate in the N / S 0.9% serum group at the time point after complete awakening of the child in recovery had a significant decrease compared to baseline condition. However, the mean arterial oxygen saturation rate in the DSS and RS groups during induction of anesthesia was significantly increased compared to baseline condition. At other time points, no statistically significant difference was observed in the groups under study compared to the baseline condition (Table 6).

The results of Kruskal-Wallis test show that the mean depth of anesthesia (BIS) at all time-points including: 30 minutes before surgery, during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after full awakening of the child in recovery was no statistically significant difference between the three groups under study (Table -7).

The results of one-way analysis of variance and Kruskal-Wallis test show that the mean blood sugar of children in all time-points including: 30 minutes before surgery, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child had statistically significant difference according to three groups under study. However the mean blood sugar of children in the DSS group was significantly higher than the N / S 0.9% serum and RS groups in all time points (Table -8).

The results of GEE test showed that the mean blood sugar in the N / S 0.9% serum group and in the RS group one hour after induction of anesthesia and after complete awakening of the child in recovery had a significant increase compared to baseline condition. In the DSS group, the mean blood sugar of children in all time-points including: 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery had a significant increase compared to baseline condition (Table -8).

Discussion

This study was carried out in order to compare the blood sugar level of children in fluid therapy with dextrose saline, Ringer and NS 0.9% serums and its relationship with the depth of anesthesia in elective surgeries.

Based on the results of the present study and according to the analyzes performed with the injection of dextrose saline and NS 0.9% serums, there was a statistically significant relationship between blood pressure and heart rate during and after surgery with patients' blood sugar. But in RS injection, only systolic blood pressure showed an increasing trend. Consistent with the results of the present study, the study of *Jiménez et.al*, showed that there was a statistically significant relationship between intraoperative blood sugar and other variables such as heart rate, oxygen saturation percentage and the respiration rate during the operation (27). On the other hand, the results of the study of *Hajian et.al* showed that fasting of children have no effect on their blood sugar but can reduce systolic blood pressure (28), which is not consistent with the results of the present study.

Data obtained from the mean depth of anesthesia (BIS) at all time-points including: 30 minutes before surgery, during induction of anesthesia, 30 minutes after induction of anesthesia, one hour after induction of anesthesia and after complete awakening of the child in recovery did not show a statistically significant difference in the mean BIS according to three groups under study, which was consistent with the study of *Haghbin et.al* in which no significant difference was observed between the control and baseline groups in the field of BIS (29).

The findings of the present study showed that in all patients in general and regardless of the independent variables studied, the blood sugar of patients in all three groups receiving therapeutic serums before anesthesia to full awakening in recovery had statistically significant increase ($P < 0.05$), which has been emphasized in reference books and previous studies on hyperglycemia during surgeries (6).

The results of the present study showed that patients receiving DSS have had higher than normal blood sugar levels before surgery until full awakening in recovery. Blood sugar levels exceeded normal in patients receiving RS from half an hour after surgery and in patients receiving NS 0.9% from one hour after surgery. *Nelson and Notinen* believe that even in cases where glucose-free fluids are consumed during surgery, hyperglycemia is still observed (30, 31). The usual use of intraoperative glucose-containing fluids in children has declined in recent years, due to the fact that blood sugar levels are maintained within the normal range or even higher during surgery, even by injecting glucose-free fluids, which is probably caused by the stress of surgery and increased insulin resistance (32).

During anesthesia and surgery, due to surgical stress, there is always the possibility of certain metabolic and hormonal changes caused by stimulation of the neuroendocrine and sympathoadrenal systems (4). The result of metabolic changes caused by endocrine changes is a large increase in plasma glucose concentration that occurs during surgery (33). Some researchers have linked high blood sugar to peripheral insulin resistance, decreased insulin secretion, or impaired insulin metabolism, and others have considered high blood sugar as a defense mechanism to meet the need for glucose in tissues, saving energy and improve intravascular volume by increasing osmolarity (28). On the other hand, a study by *Verhoeven et.al*, which was conducted to evaluate impaired glucose homeostasis after pediatric heart surgery, showed that 65% of children were prescribed glucocorticoids during surgery, this was the main factor associated with high blood sugar at the end of surgery (7). However, hyperglycemia specifically leads to a decrease in neutrophil chemotaxis, which in turn increases postoperative infection and mortality due to decreased innate immunity of the body, delayed wound healing, decreased collagen secretion, and neurological, renal and cardiovascular damages (33). Most researchers believe that hyperglycemia during surgery, if there is ischemia, also causes irreparable brain damages (34).

According to the results obtained from this study, it can be concluded that although in these surgeries that lasted more than an hour, the mean blood sugar rose 0.9% even after receiving Ringer and NS serums, and this may lead to much more drastic changes in the way patients become hyperglycemic during most surgeries, even in non-diabetic persons. A study by *Gustafsson et.al*, which aimed to evaluate the predictive value of glycosylated hemoglobin for postoperative hyperglycemia, also showed that postoperative hyperglycemia is common in patients without a history of diabetes (35).

On the other hand, comparing the stage of one hour after induction of anesthesia with after full awakening of the child in recovery, it was observed that blood sugar of people receiving NS 0.9% was increasing from stage 3 to stage 4, while in people receiving Ringer, we were witnessing a declining trend in blood sugar. It is possible that using Ringer compared with NS 0.9% is preferred with regard to side effects of hyperglycemic state. Also, based on the results of the present study, the use of DSS is not recommended due to high blood sugar in children before surgery.

According to the results of the present study, it seems that blood sugar monitoring in general anesthesia surgeries in non-diabetic patients is as important as in patients with diabetes and we recommend that blood sugar monitoring should be carried out in non-diabetic people due to the hidden symptoms of blood sugar changes during anesthesia and in order to improving the quality of monitoring and optimal maintenance of patients' health, at least in long-term surgery, before and during induction of anesthesia, and for half an hour during the operation and during waking up in recovery.

Abbreviations

NPO
Nil Per Os, EEG:Electrocardiography, RS:ringer serum, DSS:dextrose saline serum, NS:normal saline 0.9%, BMI:body mass index, BIS:Bispectral Index Monitoring, ASA:American Society of Anesthesiologists, HR:Heart rate, BP:Blood Pressure, T:Temperature, RR:Respiratory Rate, BS:Blood Sugar.

Declarations

Acknowledgement:

Authors thank the staff of Ganjavian Hospital in Dezful for their cooperation

Authors' contributions:

Dr.Farhad nanaei and Zohreh sekhavatpour managed the research. Morteza Habibi Moghadam and Dr.Zahra eslamifar done the research and wrote the main manuscript text. Hadi bahramia and Dr. Mohammad Hasan Bigdeli prepared tables and wrote a part of manuscript text. All authors reviewed the manuscript.

Funding:

There is not funder(s) of the research described in this manuscript, and the associated grant reference numbers.

Availability of data and materials:

The datasets used and/or analyzed during this study are available from the corresponding author on reasonable demand.

Ethics approval and consent to participate

This study was approved by the local ethics committee (Ethics Committee of Dezful University of Medical Sciences, Iran, No. IR.DUMS.REC.1396.32 dated January 2, 2018). The ‘informed consent’ of the guardians or parents was received via a contract.

Consent for publish:

Not applicable

Competing interests:

The authors announce that they have no competing interests.

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Tables

Due to technical limitations, table 1,2,3,4,5,6,7,8 is only available as a download in the Supplemental Files section.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- BloodSugarinFluidTherapyBMCtables.docx