PERIOPERATIVE BLOOD SUGAR LEVELS IN CHILDREN ADMINISTERED RINGER’S LACTATE AND 1% DEXTROSE RINGER’S LACTATE - A PROSPECTIVE, DOUBLE BLINDED, RANDOMIZED CONTROL STUDY

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ABSTRACT

BACKGROUND
Infants and small children are vulnerable to developing hypoglycaemia especially when kept fasting preoperatively. The practice of administering dextrose-containing intravenous solutions to children intraoperatively has declined. This study evaluates the incidence of perioperative normoglycaemia in children.

MATERIALS AND METHODS
100 children aged 6 months to 6 years who had followed standard fasting guidelines were randomized to receive either Ringer’s lactate (RL) or 1% dextrose Ringer’s lactate (1% DRL) as perioperative fluids. Blood sugar levels were estimated at induction, one hour into surgery and one hour postoperatively.

RESULTS
3/100 (3%) children had fasting blood sugar values <50 mg.dL⁻¹. In no child was hypoglycaemia observed intraoperatively. Blood sugar levels increased in all children intraoperatively; median of 98.44 mg.dL⁻¹ in the RL group and 109.64 mg.dL⁻¹ in the 1% DRL group. Intraoperative blood sugar levels were >150 mg.dL⁻¹ in 3 children administered 1% DRL group in 1 child with RL. Postoperative median blood sugar of 90 mg.dL⁻¹ were noted in 1% DRL group and 83.50 mg.dL⁻¹ in the RL group.

CONCLUSION
Intraoperative infusion of RL and 1% DRL provides normoglycaemia in the majority of children. Fasting and postoperative hypoglycaemia can occur.

KEYWORDS
Perioperative Fluid, Blood Sugar, Paediatric.

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BACKGROUND
The aim of providing appropriate perioperative intravenous (IV) fluid therapy in children is to replenish fluid deficits, provide maintenance fluid and replace intraoperative fluid, electrolyte and blood losses.¹,² Since the 1980s, the practice of administering 5% dextrose-containing paediatric IV solutions has fallen to disrepute, following documented evidence of perioperative hyperglycaemia and hyponatraemia. Ringer’s lactate is intraoperative fluid of choice both in children and adults. However, smaller children may be more vulnerable to developing dehydration and perioperative hypoglycaemia, especially if the preoperative period of fasting is prolonged.³,⁴,⁵ Providing a lower concentration of intraoperative dextrose may overcome these problems.

Aim
To compare perioperative blood sugar values in children undergoing elective surgery under general anaesthesia administering either 1% Dextrose Ringer’s lactate or Ringer’s lactate.

MATERIALS AND METHODS
This randomized, prospective, double blind study was undertaken following Institutional Ethics Committee approval and informed consent from parents or guardians. The power of the study was calculated based on a pilot study in 10 children. For an 80% power and 5% level of significance between the two groups, 80 children need to be enrolled. 100 children of either gender, aged 6 months to 6 years, of ASA physical status 1 & 2, scheduled for elective intermediate duration surgery under general anaesthesia, were included. Children scheduled for major abdominal, thoracic and cardiac surgeries involving major fluid shifts or with known endocrine disorders, full stomach and those on preoperative IV fluids, were excluded.
The children were evaluated preoperatively and those who had adhered to standard fasting guidelines i.e., 6 hours for light meal and non-human milk, 6 hours for infant formula milk, 4 hours for breast milk and 2 hours for clear non-glucose containing liquids were enrolled. Oral midazolam 0.5 mg.kg\(^{-1}\) in 2.5 mL of paracetamol syrup was administered 20 minutes prior to surgery.

A computer-generated randomization table and sealed envelope technique randomized the children into two groups of 50 each: Group RL (Ringer’s lactate) and Group 1% DRL (1% dextrose Ringer’s lactate). The 1% dextrose Ringer’s lactate solution was prepared by Observer 1 (SJ) prior to each case. After withdrawing 10 mL of Ringer’s lactate from a 500 mL bottle, 10 mL of 50% dextrose was added. (10 mL 50% dextrose contains 5000 mg of dextrose; 5000 mg in 500 mL makes a 1% solution).

**Monitoring Included**
Electrocardiogram Lead II, noninvasive blood pressure, oxygen saturation, end-tidal carbon dioxide, end-tidal anaesthesia agent monitoring. General anaesthesia was induced with oxygen, nitrous oxide (1:2) and sevoflurane (end-tidal MAC of 2.5%) via a face mask. Intravenous access was secured, and a blood sample taken (fasting blood sugar). An additional IV cannula was secured (avoiding the limb with the IV infusion) and hepled for subsequent blood sampling. Anaesthesia was maintained with oxygen, nitrous oxide (1:2), isoflurane, vecuronium, fentanyl and mechanical ventilation via an endotracheal tube or a Laryngeal Mask Airway.

Depending on the randomization, the appropriate IV solution was infused via a paediatric burette set, at the flow rate described by Berry. During the 1st hour: 25 mL.kg\(^{-1}\) for children <3 years, 20 mL.kg\(^{-1}\) for 3-4 years, 15 mL.kg\(^{-1}\) for >4 years. During the remainder of the surgery, fluid was infused at 6 mL.kg\(^{-1}\).hr\(^{-1}\). One hour after initiating the IV fluid infusion, a second blood sample was drawn. At the end of surgery, following transfer to the postoperative care unit (PACU), IV fluid was administered at 4 mL.kg\(^{-1}\).hr\(^{-1}\). One hour after the child was received in the PACU, a third blood sample was drawn.

Blood samples were immediately transported to the laboratory. The glucose oxidase method was used for blood sugar estimation. The laboratory normal blood sugar values ranged from 60 - 110 mg.dL\(^{-1}\). Hypoglycaemia was defined as a blood sugar value of ≤ 60 mg.dL\(^{-1}\) and hyperglycaemia as ≥ 150 mg.dL\(^{-1}\). The Anaesthesiology consultant (EV), was blinded to the IV fluid infused, ensured appropriate IV infusion flow rate and collection of blood samples.

Statistical analysis was performed with SPSS 11.5 data package. The Mann Whitney U test was used to compare weight, age, fasting and postoperative blood sugar values; the Chi square test for sex and incidence of intraoperative and postoperative hyperglycaemia. Repeated measures of ANOVA were used for comparing intraoperative blood sugar values and the Independent sample t test for analysis of the change in median blood sugar values. A p <0.05 were considered significant.

**RESULTS**
The demographic data and duration of surgery were comparable (Table 1) and fasting and postoperative blood sugar values were comparable in both the groups (Table 2). Fasting hypoglycaemia was noted in 4 out of 100 children (44-57 mg.dL\(^{-1}\)), 3 of whom had fasting blood sugar values < 50 mg.dL\(^{-1}\) however, none had clinical evidence of hypoglycaemia. The intraoperative median and interquartile range blood sugar values with 1% DRL and RL were 109.64 (23.95) mg.dL\(^{-1}\) and 98.44 (21.18) mg.dL\(^{-1}\) respectively (p=0.015). Three children with 1%DRL and one with RL had intraoperative blood sugar values in the higher range of 153-165 mg.dL\(^{-1}\). One child with RL had an intraoperative blood sugar value 53 mg.dL\(^{-1}\). The median and interquartile range of the increase in blood sugar values from the fasting to intraoperative period was 18.50 (90) mg.dL\(^{-1}\) with 1% DRL and 11.00 (65) mg.dL\(^{-1}\) with RL respectively, (p =0.001) (Table 3).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1% DRL n=50</th>
<th>RL n=50</th>
<th>p Value</th>
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<tbody>
<tr>
<td>Age (months)</td>
<td>26 (28.50)</td>
<td>36 (27.75)</td>
<td>0.137* (NS)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Weight (kg)</td>
<td>10.75 (4.6)</td>
<td>11.00 (5.10)</td>
<td>0.507* (NS)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>25: 25</td>
<td>16: 34</td>
<td>0.067**(NS)</td>
</tr>
<tr>
<td>Female: Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration (min)</td>
<td>73.50 (40)</td>
<td>87.50 (62.25)</td>
<td>0.098*(NS)</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td></td>
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</tr>
</tbody>
</table>

Table 1. Demographic Data & Duration of Surgery

IQR - Inter quartile range, * Mann Whitney U Test, **Chi square test, NS - not significant, SS - statistically significant
The median and interquartile range blood sugar values taken 1 hour postoperatively, were 83.50 (24.75) mg.dL⁻¹ with RL and 90.00 (37.75) mg.dL⁻¹ with 1% DRL.

Four children (3 with RL and 1 with 1% DRL) had blood sugar values below 60 mg.dL⁻¹ (2 children with RL blood sugar values <50 mg.dL⁻¹) Postoperative 2 children one in each group had blood sugars values >150 mg.dL⁻¹

**DISCUSSION**

There is a lingering fear among anaesthesiologists that hypoglycaemia may go unrecognized in infants and young children under anaesthesia. From this fear stemmed the practice of infusion of 5% glucose-containing paediatric IV solutions intraoperatively. It is established that despite prolonged periods of fasting the incidence of hypoglycaemia is reported to be 2.2 to 10% in children aged 3 months to 10 years of age. Hypoglycaemia can be primarily avoided by following standard fasting guidelines and allowing glucose-containing clear fluids till 2 hours preoperatively. Fasting hypoglycaemia was 4% in this study (blood sugar < 60 mg. dL⁻¹) and in 2% of children <50 mg.dL⁻¹ (hypoglycaemia in children is generally defined as < 50 mg dL⁻¹). It is rather impractical for the fasting guidelines to be accurately followed, especially with scheduling delays. In reality, the true incidence of fasting hypoglycaemia may be more common than this study reports.

Administration of glucose-free isotonic solutions intraoperatively to children is now the norm. It may be worthwhile to administer low dextrose-containing IV fluids intraoperatively and ensure a normoglycaemia state into the postoperative period as well. The development of hypoglycaemia during surgery is unlikely, given that the stress response to anaesthesia and surgery often causes a rise in blood sugar. Though intraoperative hypoglycaemia was noted in one child with RL in this study. Welborn LG and colleagues who reported higher values postoperatively. This implies that blood sugar values declined possibly with reduction in postoperative stress hormonal levels. Sparse data is available on postoperative blood sugar values in children. Similar observations have been made by Dubois MC and colleagues who reported higher values postoperatively with 1% and 2.5% dextrose 0.4 saline compared with RL.

An important observation in this study is that postoperative blood sugar values were lower than fasting and intraoperative values. 2 children with RL had blood sugar values < 50 mg.dL⁻¹ postoperatively. This implies that blood sugar values decline possibly with reduction in postoperative stress hormonal levels. Sparse data is available on postoperative blood sugar values in children. Similar observations have been made by Dubois MC and colleagues who reported higher values postoperatively with 1% and 2.5% dextrose 0.4 saline compared with RL. Should a higher concentration of glucose of 2-2.5% be provided in children perioperatively? Would these maintain normoglycaemia intraoperatively well into the postoperative period when the child continues to be kept nil per oral?

The infusion of isotonic solutions with 1-2.5% dextrose perioperatively in children is now well established. In 2010 September the European Society for Paediatric Anaesthesiology recommended that an intraoperative fluid should have an osmolality close to the physiological range to avoid hyponatraemia and an addition of 1-2.5% instead of 5% dextrose be administered to avoid hypoglycaemia, lipolysis or hyperglycaemia and that it should include metabolic anions (acetate, lactate or malate) as bicarbonate.
precursors to prevent hyperchloremic acidosis. The underlying intensity of this consensus statement is to facilitate the granting of a marketing authorization for such a solution with the ultimate goal of improving the safety and effectiveness of intraoperative fluid therapy in children. These are commercially available in Europe, unfortunately not in many countries outside of Europe. As a consequence, many anaesthesiologists tend to use suboptimal intravenous fluid strategies that may lead to iatrogenic hyponatraemia, hyperglycaemia or medical errors.

There are some weaknesses in this study. Though 100 children were enrolled, this number was inadequate to perform an appropriate age-related sub analysis of data. The biochemical analysis of blood sugars was done in the laboratory by the glucose oxidase method which is an accepted as the most accurate method of measurement.

However, drawing and transportation delays as well as delays in receiving reports were a cause of frustration. In retrospect, a simultaneous bedside analysis with a glucometer would have provided immediate values. Due to financial constraints two methods of evaluation could not be used and the more accurate though tedious method was chosen. Since children who had not strictly followed fasting guidelines were excluded, the values of fasting blood sugar do not reflect the ground reality; often children are kept fasting for longer periods both pre and postoperatively.

Further studies with a larger population and a subgroup analysis would throw more light on this problem. The effect of other factors which may affect perioperative blood sugar levels e.g., regional analgesia with or without analgesic supplements, also needs to be analysed.

CONCLUSION

Despite following current NPO guidelines, hypoglycaemia can occur in children preoperatively. Infusion of 1% dextrose Ringer’s lactate or Ringer’s lactate in the intraoperative period provides normoglycaemia in the majority of children.

REFERENCES