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Perioperative blood glucose in a paediatric daycase facility: Effects of fasting and maintenance fluid

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ABSTRACT

Background: Many Children are daily exposed to prolonged preoperative fasting time. The choice of intraoperative maintenance fluid continues to be an issue of controversy. This study assesses the duration of preoperative fast among children undergoing ambulatory surgery and the appropriateness of the maintenance solutions used. **Patients and Methods:** Seventy-eight children undergoing ambulatory surgery were prospectively randomised to receive lactated Ringer's (LR) solution or 4.3% dextrose in 0.18% saline (DS) as maintenance fluid. The duration of preoperative fast was noted and the blood glucose measured at induction, but before infusion of any intravenous fluid, and subsequently every 30 min. Data were analysed with Statistical Packages for the Social Sciences 16.0 (SPSS incorporated, Chicago Ill, USA). $P < 0.05$ was considered as significant. **Results:** The age range was 3 months to 15 years (mean = 4.9 ± 3.6 years); mean weight was 16.3 ± 7.8 kg. The mean duration of fasting was 13.4 ± 3.5 h (range = 4-18.5 h), but no child was hypoglycaemic throughout the study. The mean blood glucose in the LR group rose steadily from 5.18 ± 0.98 mmol/L post-induction to a peak value of 7.40 mmol/L at 120 min. In the DS group, the mean blood glucose level increased from the post-induction value of 5.56 ± 0.86 mmol/L to 12.7 ± 3.98 mmol/L at 120 min. **Conclusion:** Most children undergoing ambulatory surgery at our facility are still exposed to prolonged fasting time. Glucose containing fluid often administered as maintenance fluid to treat the presumed hypoglycaemia causes worsening hyperglycaemia, which may be harmful.

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Key words: Ambulatory surgery, blood glucose, developing country, hyperglycaemia, hypoglycaemia, paediatric anaesthesia, perioperative fluid, preoperative fasting

INTRODUCTION

Preoperative fasting is an established practice in anaesthesia aimed at minimising the risk of regurgitation and aspiration of gastric contents. Despite the liberalisation and reduction in the duration of preoperative fasting in the 1990s,[1] most children in developing countries continue to undergo prolonged preoperative fast.[2-4] Although several clinicians have reported maintenance of normoglycaemia preoperatively, and hyperglycaemic response to surgery and anaesthesia in healthy children in spite of fasting;[5-14] others have observed hypoglycaemia in a significant minority.[3,15-23] Failure to demonstrate hyperglycaemia or outright hypoglycaemic response to anaesthesia and surgery has been reported by a few.[19,24] A high incidence of preoperative hypoglycaemia was observed among low percentile weight children (40%) by Ilori *et al*.[3] Hypoglycaemia could be a cause of significant morbidity and mortality in the perioperative periods.

It has been suggested that glucose free solutions may be safely used during paediatric surgery.[11] However, its safety in the setting of prolonged fasting often observed in developing economies has not been adequately evaluated. Furthermore, there is paucity of data on the effect(s) of commercially available maintenance solutions on perioperative blood glucose and the incidence of postoperative hypoglycaemia in paediatric daycase surgery. Various concentrations of glucose in lactated Ringer's (LR) solution have been used against LR solution as intraoperative fluid. These include 5%, 2.5%, 2%, and 1%.[14-24] However, these are not commercially available in many centres in the sub-Sahara and the pharmacy departments may

not be adequately equipped to handle production of these fluids. Currently 4.3% dextrose in 0.18% saline (DS) is the fluid being used in many centres in Nigeria for paediatric perioperative fluid management. The suitability of this fluid in children has not been well investigated in our patients and perioperative blood glucose is not routinely checked in our environment because of limited resources. It is also noteworthy that many of the previous studies were done decades ago. This study was conducted to assess the effect of fasting and commonly used intraoperative fluids in our hospital on perioperative blood glucose in children undergoing daycase surgery. The aims were to: Assess the duration of fasting and its effect on preoperative blood glucose in children undergoing daycase surgery; and determine the effects of commercially available glucose-free and glucose containing solutions on their perioperative blood glucose.

PATIENTS AND METHODS

This was a prospective randomised study. All children with age ranging from 3 months to 15 years scheduled for ambulatory surgery associated with minimal blood loss including herniotomy, circumcision, orchidopexy, lump excision, eye surgery at the daycase theatre of our hospitals during the study period were recruited into the study. Ex-premature infants, children with cardiac, neurological, endocrine, or metabolic diseases were excluded. Ethical approval was obtained from the Clinical Research Ethics Committee of the Hospital.

The sample size of 78 computed using the equation by Snedecor and Cochran[25] (for Studies comparing two group means, $n = 1 + 2C\,(s/d)^2$) was used where: s (the standard deviation) = ±0.9 mmol/L based on a previous pilot study; d (the difference in blood glucose to be detected) = 0.5 mmol/L; C is a constant dependent on the value of α- and β-selected; α (the alpha level) = 0.05 and 1-β = (1-power), that is, the chance of obtaining a false-negative result = 0.9, C is 10.51. Using stratified randomisation with sealed envelopes labelled by stratum, the children were categorised into three age-groups namely: Group I: 6 months to 2 years; Group II: 2-6 years; and Group III: 6-15 years, with 26 children in each of the three age-groups. Within each group, each child either received LR solution alone or 4.3% DS as intraoperative fluid.

Standard preoperative instruction regarding fasting was given to the parents/guardians of the patients during preoperative visit. Infants were allowed breast milk up to 4 h and clear fluids up to 2 h before induction of anaesthesia. Older children were fast overnight but allowed clear fluid up to 2 h pre-induction. After explanation of the purpose and nature of the study to the parent/guardian accompanying the patient, informed consent was obtained. Information about the time and nature of the last meal and the last drink of the patient was collected. The child's age, gender, weight, and height were recorded.

Atropine was administered at a dose of 0.01 mg/kg after halothane induction. Anaesthesia maintained with halothane/air/oxygen mixture while intraoperative analgesia was provided with intravenous paracetamol at a dose of 10-15 mg/kg, and lidocaine infiltration at the end of surgery. The blood glucose test was performed using Accu-Chek® Advantage® blood glucose monitoring system (Boehninger Mannheim Corporation., Indianapolis, IN, USA). The Accu-Chek® Advantage® blood glucose monitoring system has been found to be accurate (i.e., reading falls within a 20% variance in either direction of a laboratory analysed specimen taken at the same time), demonstrating excellent correlation with a value of 0.994.[26] The preoperative blood glucose determination was performed immediately after induction (T_0) but before infusion of any intravenous fluid, and subsequently at 0.5 h (T_1), 1 h (T_2), 1.5 h (T_3), and 2 h (T_4). The duration of the surgery was recorded. The hourly maintenance rate (ml/h) of fluids infused during surgery was calculated using the formula devised by Holliday and Sega and modified by Oh.[27] A hydrating bolus of half the calculated deficit incurred during the fast was infused during the 1st hour of surgery.

Data were entered into the Statistical Packages for the Social Sciences 16.0 (SPSS incorporated, Chicago III, USA). Discrete categorical data were presented as frequencies or proportions of total; and continuous data were presented as means and standard deviations (mean ± SD). Blood glucose levels between the groups were compared using Student's t-test. A $P < 0.05$ considered as statistically significant. For the purpose of this study, hypoglycaemia was defined as ≤3.0 mmol/L and hyperglycaemia >10 mmol/L.

RESULTS

Seventy-eight children were included in the study comprising of 74 males and 4 females. The age ranged from 3 months to 15 years with a mean of 4.9 years ± 3.6 years, while their weight ranged from 4 kg to 48 kg with a mean of 16.3 kg ± 7.8 kg. The mean duration of fasting was 13.4 h ± 3.5 h and ranged from 4 h to 18.5 h. They all had

general anaesthesia for their surgery and the mean duration of anaesthesia and surgery was 56.8 min ± 24.4 min, with a range of 30-156 min. The age, weight, height, duration of fasting, and duration of anaesthesia and surgery were comparable between the two groups as shown in Table 1. The age distribution of the children is shown in Figure 1, while the surgical procedures performed on the children are shown in Figure 2.

Sixty-five per cent of the children had fasted for 12-16 h before induction of anaesthesia [Figure 3]. However, the post-induction (T_0) blood glucose ranged from 3.3 mmol/L to 8.3 mmol/L [Figure 4]. The least blood glucose at T_0 was recorded in a 2 years and 4-month-old boy in LR group who had fasted for 15 h before anaesthesia for hydrocelectomy on account of vaginal hydrocele. The highest blood glucose was recorded in a 10-year-old boy in DS group who had right sided orchidectomy on account of undescended testis. The boy had fasted for 16 h before induction of anaesthesia. The highest blood glucose level recorded during the study was 15.2 mmols/L. It was recorded at T_3 (90 min post-induction of anaesthesia) in a 9-year-old boy in DS group who had herniotomy for inguinoscrotal hernia. No child was found to be hypoglycaemic throughout the study.

There was no significant difference in the mean blood glucose level of LR group and the DS group at T_0 (immediately post-induction) as shown in Table 2

Table 1: Demographic characteristics of the two groups (mean ± SD)

Parameter	LR (n = 39)	DS (n = 39)	P value
Age (years)	5.06±3.78	5.14±4.55	0.93†
Weight (kg)	15.70±6.52	15.94±9.33	0.90†
Height (cm)	107.42±16.06	115.83±21.55	0.22†
Duration of fasting (h)	13.37±3.31	13.45±3.81	0.93†
Duration of anaesthesia and surgery (min)	57.46±26.87	56.0±21.69	0.81†

†Not statistically significant. SD: Standard deviation; DS: 4.3% dextrose in 0.18% saline; LR: Lactated Ringer's

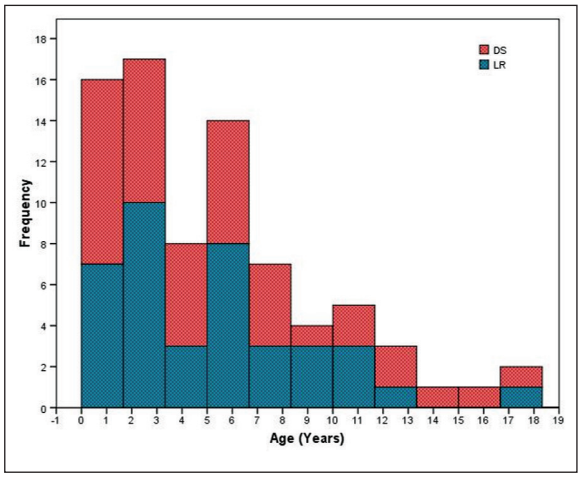


Figure 1: Age distribution of all the children

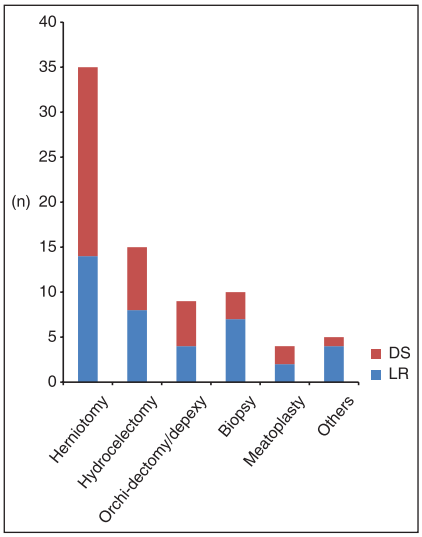


Figure 2: The type of surgery performed on all the children. *P*-0.25 (difference is not statistically significant)

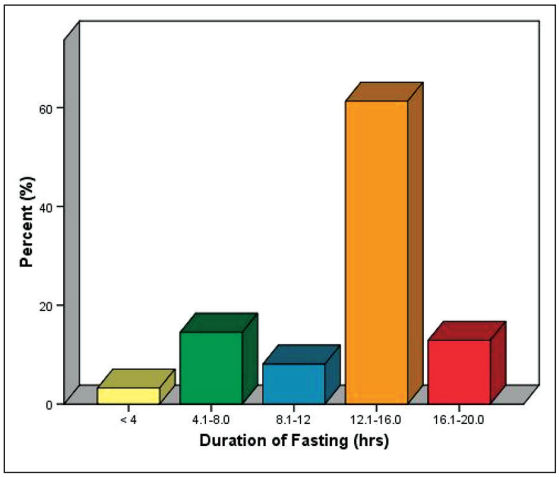


Figure 3: Distribution of duration of fasting in all patients

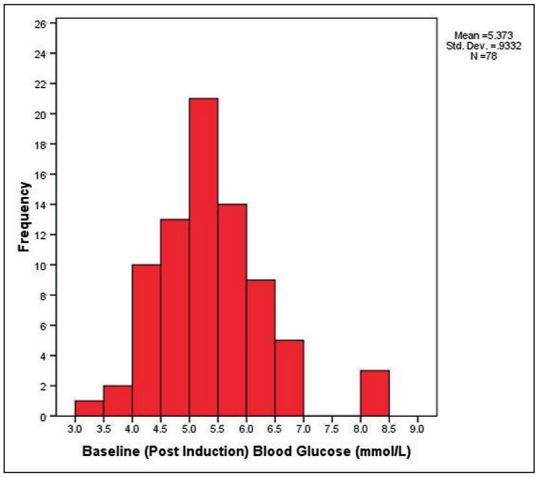


Figure 4: Distribution of baseline (post-induction) blood glucose in all children

(P = 0.07). In the LR group, the mean blood glucose rose steadily from the post-induction (T_0) level of 5.18 mmol/L ± 0.98 mmol/L to a peak value of 7.40 mmol/L at T_4. Only one child (11.1%; n = 9) in the LR group had blood glucose in the hyperglycaemic range (10.4 mmol/L), and this was at T_3. In the DS group, the mean blood glucose level increased during anaesthesia and surgery from the post-induction (T_0) value of 5.56 mmol/L ± 0.86 mmol/L to a hyperglycaemic level of 12.7 mmol/L ± 3.98 mmol/L at T_4 [Table 2]. Hyperglycaemia was observed in 5.1% (n = 39), 25% (n = 24), 50% (n = 4) and 66% (n = 3) of the children in DS group at T_1, T_2, T_3, and T_4 respectively [Figure 5]. Significant differences were observed between the two groups at T_1, T_2 and T_3 when the DS group entered hyperglycaemic range with P values of 0.0001, 0.0001, and 0.048, respectively [Table 2]. Though the least recorded mean blood glucose value was in the age group I of the LR (4.88 mmol/L ± 0.86 mmol/L) at T_0 (immediate post-induction) [Table 3], the children in this group also demonstrated increase in blood glucose in response to anaesthesia and surgery.

DISCUSSION

The current preoperative fasting guideline recommends a fast of at least 6 h following intake of solids or non-human milk, 4 h following human milk, and 2 h following clear fluids. Prolonged fasting is associated with significant patient discomfort. It may also lead to dehydration, biochemical imbalance and hypoglycaemia, especially in children, and has been discouraged in anaesthetic and surgical practice. However, prolonged fasting remains prevalent in many centres around the world including Nigeria.[28] This study shows that our paediatric patients are exposed to an average of over 13 h fasting before anaesthesia and surgery. This finding is similar to the report of Soyannwo and Sanusi[2] at Ibadan close to two decades ago where 62.5% of 64 children below the age of 12 years had fasted for more than 12 h before induction of anaesthesia. Bode *et al*.[4] in Lagos, Nigeria reported a similar finding about the same time. The 112 children in their study with age ranging from 2 weeks to 14 years had fasted for over 11 h before anaesthesia. In another report by Ilori *et al*.[3] in Calabar, Nigeria in 2005, 74% of the 50 children studied with age between 6 months and 6 years fasted in excess of 12 h.

The 'nothing by mouth after midnight' rule for elective surgery is still being applied to across board irrespective of patient's age more than two decades after liberalisation and reduction in the duration of preoperative fasting.[1] Although, this rule simplifies preoperative instructions, it also results in prolonged fasting period of 12 h or more. Most of the children

Table 2: Changes in blood glucose concentration in the LR and DS groups with time (values are mean ± SD in mmol/L)

Time	LR (n)	DS (n)	P value
T_0	5.18±0.98 (39)	5.56±0.86 (39)	0.07†
T_1	5.99±1.10 (39)	8.03±1.62 (39)	0.0001‡
T_2	6.56±1.67 (26)	8.81±2.51 (24)	0.0001‡
T_3	7.33±1.35 (9)	11.05±4.85 (4)	0.048‡
T_4	7.40±0 (1)	12.70±3.98 (3)	0.368†

†Not statistically significant; ‡Statistically significant. SD: Standard deviation; DS: 4.3% Dextrose in 0.18% saline; LR: Lactated Ringer's

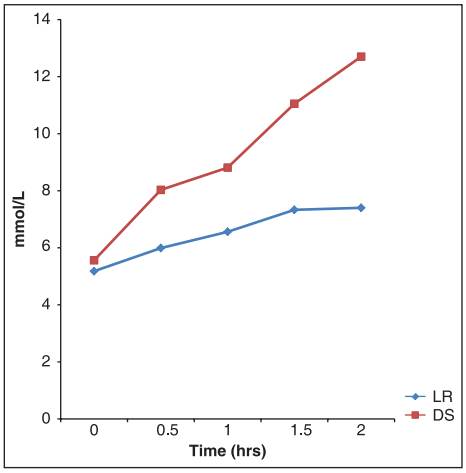


Figure 5: Mean blood glucose plotted against time

Table 3: Changes in blood glucose in each of the three age groups against time (values are mean±SD in mmol/L)

Time	T_0 (n)	T_1 (n)	T_2 (n)	T_3 (n)	T_4 (n)
Group I					
LR	4.88±0.58 (13)	5.75±1.24 (13)	5.89±1.71 (11)	7.56±1.94 (4)	—
DS	5.63±0.80 (13)	8. 66±1.72 (13)	8.82±3.58 (5)	—	—
Group II					
LR	5.11±1.09 (13)	6.00±1.20 (13)	6.93±1.50 (11)	7.30±0.0 (2)	—
DS	5.38±0.88 (13)	7.27±1.33 (13)	8.48±2.32 (9)	15.20±0.0 (1)	15.00±0.0 (1)
Group III					
LR	5.64±1.09 (13)	6.26±0.75 (13)	7.43±1.69 (4)	7.03±1.19 (3)	7.40±0.0 (1)
DS	5.68±0.96 (13)	8.00±1.53 (13)	9.10±2.33 (10)	9.67±4.88 (3)	11.55±4.88 (2)

SD: Standard deviation; LR: Lactated Ringer's; DS: 4.3% dextrose in 0.18% saline

were presented on the morning of surgery with no extra meal besides the previous day supper which was taken rather early; presumably between 7.00 pm and 9.00 pm. Uncertainty about the starting time of scheduled surgical list, delay and subsequently increase duration of fasting occasioned by challenges with supplies of electricity, water, sterile consumables and medical gases remains a peculiar problem with developing nations including our, and was contributory to the prolonged fasting observed in these children.

Prolonged preoperative fasting is undesirable and should be avoided. While and Crawford[29] in a review of 10 paediatric daycase surgical admissions in the United Kingdom in 1992 identified excessively prolonged preoperative fasting and inadequate information given to parents as contributory factors to increased morbidity. There is need for improvement in information concerning preoperative fasting given to parents to prevent excessively prolonged fasting of children. As the minimum fasting duration is being communicated to parents, the maximum fasting period of 6 h should not be underplayed. An otherwise healthy child (American Society of Anaesthesiologists I and II) for daycase surgery should be encouraged to drink clear fluids up to 2 h prior to the start of the surgery list. Those who have been fasted for fluids for more than 6 h should be considered for maintenance intravenous fluids where possible. However, extra nursing manpower requirement and challenges with intravenous cannulation of an awake child may be a limitation to this option. In instances where start-up time of surgical list is certain and the time of surgery of a child can be predicted, those to be operated on in the afternoon may be given a light early breakfast. Unanticipated cancellation of cases booked for early or morning surgery due to evolving upper airway infection or other reasons sometimes occur and disrupt timing of elective list. It is also not unusual for patients to fail to turn up for scheduled surgery. These are some of the factors militating against appropriate preoperative fasting of paediatric patients.

This study showed that the risk of perioperative hypoglycaemia in healthy children undergoing daycase surgery is minimal. It is in keeping with the finding of Chin *et al*.[28] in their study of 50 healthy adults randomised to glucose and non-glucose containing fluid as initial intravenous replacement fluid in elective surgery. The evidence for hypoglycaemia resulting from prolonged preoperative fasts is conflicting. In one study, 14% of healthy young women had serum glucose of 2.5 mmol/L or less after a preoperative fast exceeding 12 h; none of them, however, were symptomatic.[2] On the other hand, the absence of preoperative and intraoperative hypoglycaemia, even when surgery is prolonged, has also been demonstrated by others[3] in keeping with our finding. To the contrary, a statistically significant rise in blood glucose from baseline was observed in all the three groups of children. A number of factors may be responsible for this including catabolic response to anaesthesia and surgery leading to increased glycogenolysis and gluconeogenesis with reduction of glucose clearance. This is related to insulin resistance which has been demonstrated following even minor surgical procedure like herniorraphy. A randomised controlled trial of 23 adults undergoing laparoscopic cholecystectomy to either conventional preoperative fasting of 8 h or 200 ml of a carbohydrate beverage 2 h before surgery by Faria *et al*.[30] showed that prolonged fasting is associated with insulin resistance. Shortened fasting duration was shown to also reduce other biochemical parameters associated with metabolic response to trauma. Prolonged fasting observed in our patient may have worsened insulin resistance and the hyperglycaemia observed in our patients. Although, this study did not assess the incidence of postoperative nausea and vomiting in the patients, it is important to note that prolonged preoperative fast has been associated with significant patient discomfort and higher incidence of postoperative nausea and vomiting which may increase re-admission rate and cost of care.[30,31]

The finding of our work suggests that glucose free maintenance fluid (LR) is probably safer in our paediatric patients undergoing minor surgical procedure on ambulatory basis than the commonly used 4.3% DS. At 90 min post-induction, 50% of children receiving 4.3% DS were hyperglycaemic with mean blood glucose of 11.05 ± 4.85 mmol/L compared with 7.33 ± 1.35 mmol/L in the glucose free group. Though previously considered an appropriate response to stress, hyperglycaemia is now known to increase the risk of postoperative complications and death.[30] Fluid balance and immune function disturbance as well as promotion of inflammation have been associated with hyperglycaemia.[32] Its effects on the body systems including polyneuropathy, immunosuppression, nosocomial infections and impaired wound healing will negatively impact outcome of ambulatory surgery services.

CONCLUSION

Prolonged fasting remains prevalent in many centres around the world including ours. There is need for

improvement in information concerning preoperative fasting given to parents to prevent excessively prolonged fasting of children. The commonly administered 4.3% DS to treat the presumed hypoglycaemia often cause severe hyperglycaemia, which is known to have negative impact on outcome of surgery. Balanced salt solution (LR solution) appears safer and should be encouraged as perioperative maintenance fluid.

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