ORIGINAL ARTICLE

Glucose: A Reevaluation of its Intraoperative Use in Paediatric Surgery

S K Lim, MMed, S P Loh, FFARACS, Department of Anaesthesiology and Intensive Care, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur

Summary

Blood glucose concentration was measured in 100 children immediately before and during surgery. These children were randomly assigned to receive either lactated Ringer's (LR) solution or 5% dextrose in lactated Ringer's (5%D/LR) intraoperatively as maintenance and replacement fluids. Blood samples were taken immediately after induction of anaesthesia and at $^1/_2$, 1, 1.5, 2 and subsequent hours. Blood glucose concentration was assayed by a reflectance meter. None of the patients was noted to be hypoglycaemic pre- and intraoperatively. Intraoperative blood glucose concentration increased significantly ($p<0.05$) from preoperative levels for both groups of children but the increase in those that received 5%D/LR was significantly greater ($p<0.05$) than those who received LR. The number of children who were hyperglycaemic during surgery was also greater in those who received 5% dextrose in lactated Ringer's as their intraoperative fluid. These data suggest that lactated Ringer's alone is a safe and appropriate fluid for intraoperative fluid therapy in children.

Key Words: Anaesthesia, Paediatric, Blood, Glucose

Introduction

Preoperative hypoglycaemia has been reported in children with an incidence of 10-25%[1,2,3,4]. The concern over this hypoglycaemia leading to intraoperative hypoglycaemia which may be undetected during anaesthesia cause many anaesthetists to recommend the routine use of glucose containing solutions during anaesthesia[2,3,5]. However, recent evidence suggests that intraoperative glucose may be undesirable in certain circumstances. In view of this, this study was undertaken to examine whether glucose solution is needed intraoperatively in paediatric surgery and to determine the trend of blood glucose concentrations intraoperatively in children who received either LR solution or 5%D/LR solution.

Methods

The study included 100 children (ASA physical status I or II) aged 1 month to 8 years, scheduled for elective paediatric surgery. Institutional approval was obtained and parental consent taken for all the children studied. Children who underwent short surgical procedures lasting a duration of $^1/_2$ hour or less and children with neurologic, cardiac, metabolic and endocrine diseases as well as those receiving intravenous dextrose solution prior to anaesthesia were excluded. The children were divided randomly into two groups for intraoperative fluid management, Group A received LR as maintenance and replacement fluid and Group B received 5%D/LR. They were allowed to drink clear fluids or breast milk up to 4 hours before anaesthesia, or formula milk up to 6 hours before anaesthesia. No solids were given after midnight.

All children were premedicated with either oral trimeprazine, 3mg/kg or oral diazepam, 0.5 mg/kg, 1 to 2 hours before anaesthesia. Anaesthesia was induced with halothane and nitrous oxide in oxygen or intravenous thiopentone 4mg/kg for older children and maintained with 70% nitrous oxide in oxygen, 0.5% - 1% halothane. Fentanyl, 1 ug/kg was given at induction and repeated when necessary. Atracurium 0.5 mg/kg was used to facilitate intubation and further muscle relaxation was maintained by either boluses of atracurium 0.1 - 0.2 mg/kg or by infusion at 0.4 mg/kg/hr. Intravenous fluids were administered to replace the fluid deficit incurred during fasting, and to maintain the fluid balance required during surgery including fluid loss resulting from surgical procedure (Table I). Plasma and blood were given as required.

Table I
Intraoperative fluid management

Maintenance Fluid	
<10kg	- 4ml/kg/hr
11-20kg	- 40ml+2ml/kg(above 10kg)/hr
> 20kg	- 60ml+1ml/kg(above 20kg)/hr
Replacement of third space loss	
Mild tissue trauma	- 2ml/kg/hr
Moderate tissue trauma	- 4ml/kg/hr
Severe tissue trauma	- 6ml/kg/hr

Immediately after induction, a capillary blood sample was taken by finger prick for blood glucose concentration determination. An intravenous cannula was inserted in the opposite limb for intravenous infusion. Further blood samples were taken at $^1/_2$, 1, $1^1/_2$, 2 and subsequent hours depending on the length of the surgery. The blood samples were analysed by using a reflectance meter (Glucometer®, Ames)[7,11]. The results were available immediately so that the possibility of hypoglycaemia was avoided. Hypoglycaemia was defined as a blood glucose concentration of less than 2.6 mmol/l[12] and hyperglycaemia as greater than 11 mmol/l[13,14]. Any patient with a blood glucose concentration of less than 2.6 mmol/l at any time was excluded from the study and intravenous glucose solution immediately commenced.

The data was analysed statistically using Student's t-test and linear regression. A p value of less than 0.05 was considered significant.

Results

The mean age, weight, duration of fasting and preoperative blood glucose concentrations in the two groups are shown in Table II. There were no differences between the 2 groups with respect to age, weight, duration of fasting and preoperative blood glucose concentration. The age distribution is shown in Fig. 1. The types of surgery, amount of fluid infused during surgery and the duration of surgery were not significantly different in the 2 groups (Table III).

The distribution of preoperative blood glucose concentrations of all the patients is shown in Fig. 2. No significant correlations were obtained between preoperative blood glucose concentrations and age or duration of fasting (Fig. 3 and Fig. 4). None of the patients were hypoglycaemic preoperatively or during surgery. The lowest blood glucose concentration seen preoperatively was 2.6 mmol/l for a 24-month-old child after 7 hours of fasting. Four of the patients (4%) were seen to be hyperglycaemic preoperatively (11.2 to 11.5 mmol/l) even though they were fasted

Table II
Mean age, weight, duration of fasting and preoperative blood glucose concentration
Mean ± SD values are given

Private	n	weight (kg)	age (months)	duration of fasting (h)	preop. glucose conc (mmol/l)
Group A	50	9.7 ± 4.3	22.5 ± 18.5	7.7 ± 2.7	6.1 ± 1.9
Group B	50	11 ± 3.2	29.8 ± 21.2	6.2 ± 2.0	6.1 ± 2.2

Group A = lactated Ringer's
Group B = 5% dextrose in lactated Ringer's

Table III
Types of surgery, duration of surgery and amount of fluid infused intraoperatively
Mean ± SD values are given

	Group A	Group B
Types of surgery		
Laparatomy	18	22
Urological	18	15
Perineal	10	8
Miscellaneous eg.closure of colostomy	4	5
Amount of fluid infused (ml)	254.2ml ± 55.4	241.0ml ± 78.2
Duration of Surgery (min.)	131.0 ± 62.6	121.4 ± 45.3

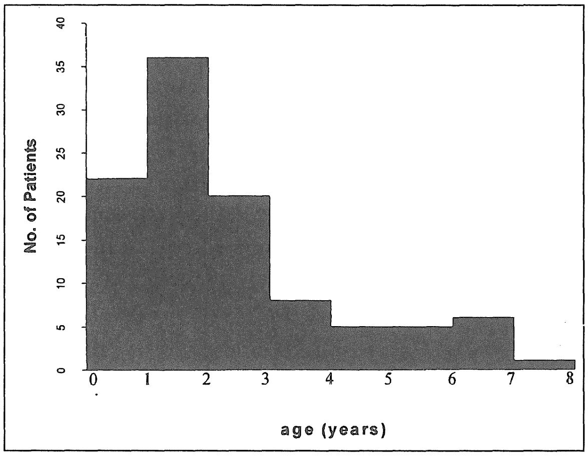

Fig. 1: Age distribution of patients

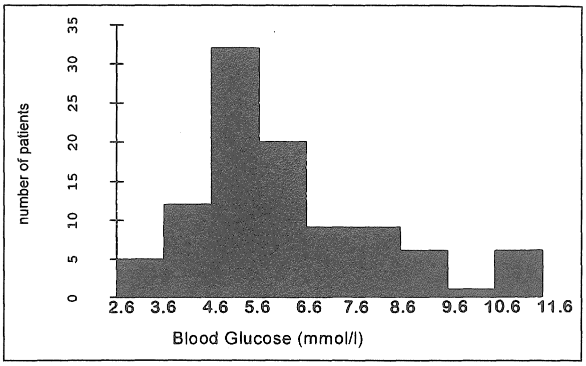

Fig. 2: Distribution of preoperative blood glucose concentrations in all patients

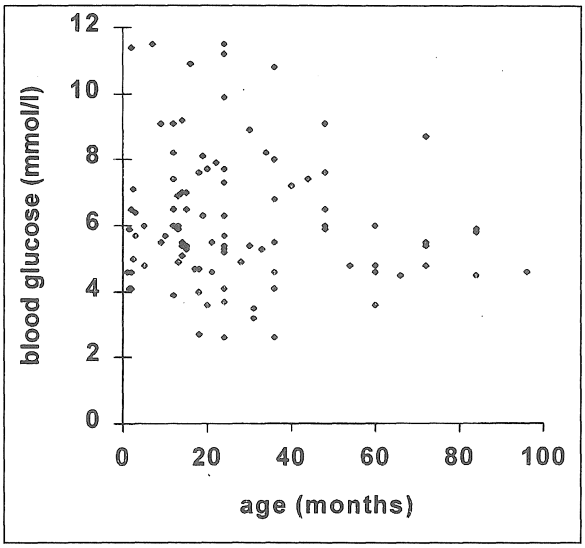

Fig. 3: Correlation between preoperative blood glucose concentrations and age

from between 5 to 10 hours without receiving any intravenous infusions during these periods.

The blood glucose concentrations increased during surgery for both Group A (LR) and Group B (5%D/LR). The levels peaked at 2 hours and thereafter they gradually declined towards the preoperative levels (Fig. 5). The increase in blood glucose concentration was greater in patients in Group B. A significant difference between the mean blood glucose concentrations of patients in Group A (LR) and Group B (5%D/LR) at $^1/_2$, 1, $1^1/_2$ and 2 hours from the commencement of the surgical procedures, was observed. However, the difference was not statistically significant thereafter. After the initial $^1/_2$ hour, patients in Group B tended to be hyperglycaemic (blood glucose concentration > 11 mmol/l) while those in Group A remained normoglycaemic throughout the period of study (Fig. 5). There were more patients who were hyperglycaemic during surgery in Group B (5%D/LR) (Fig. 6).

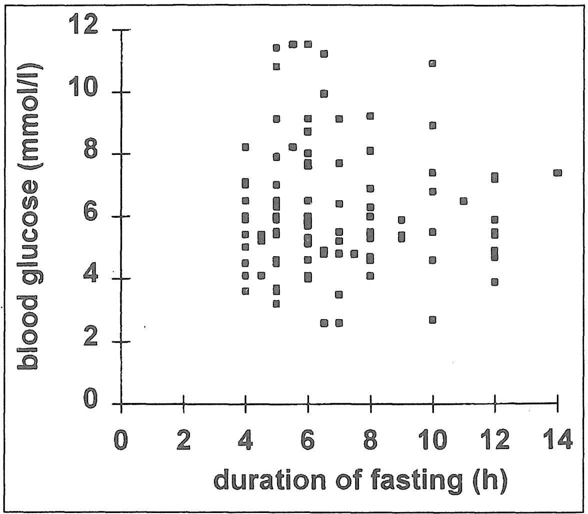

Fig. 4: Correlation between preoperative blood glucose concentrations and duration of fasting

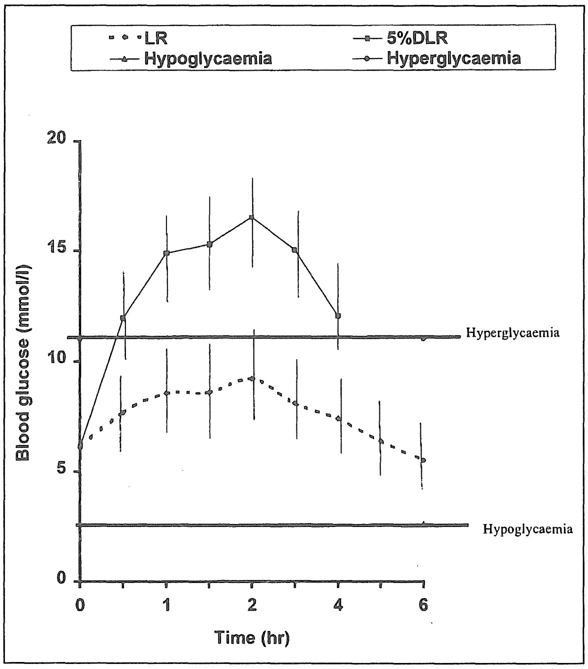

Fig. 5: Mean blood glucose concentrations (S.D.) during anaesthesia

Discussion

The possibility of hypoglycaemia during fasting and during surgery has prompted many anaesthetists to

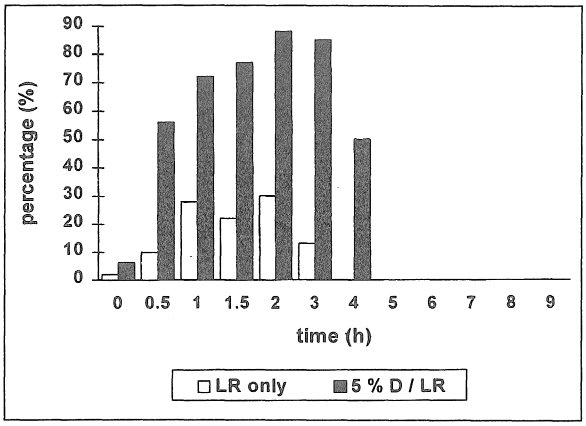

Fig. 6: The percentage of hyperglycaemic patients intraoperatively

routinely use glucose containing fluids during surgery for maintenance and for replacement of third space loses[1,2,3,4]. This is because of the fact that many of the children who are hypoglycaemic may be asymptomatic under anaesthesia as some of the signs of hypoglycaemia are lost. The question of whether preoperative fasting causes hypoglycaemia in healthy children has not been resolved[1,2,3,6]. Our study showed that even up to 12 hours of fasting, none of our patients became hypoglycaemic. Except for 1 patient who had a preoperative blood glucose concentration of 2.6 mmol/l, the rest of the patients had preoperative blood glucose concentrations greater than 3 mmol/l.

As anticipated, blood glucose increased during surgery irrespective of whether a glucose containing solution was used. However, those who received a glucose containing solution showed a greater increase in blood glucose concentration. This is in concordance with previous studies[4,6]. As seen from our results, patients who received a glucose containing solution were more likely to be hyperglycaemic (blood glucose concentration > 11 mmol/l) while those who received LR alone were normoglycaemic albeit higher than the preoperative levels.

The hyperglycaemic response seen intraoperatively is due to several possible factors including impaired insulin secretion, decrease peripheral glucose utilization, increased gluconeogenesis or glycogenolysis and increased catabolic processes[15,16]. These 'stress responses' may well be mediated by an increase in the activity of cortisol, adrenaline or glucagon.

Experimental studies have demonstrated deleterious effects due to hyperglycaemia on the neurologic outcome of animals subjected to cerebral or spinal ischaemia, hypoxia or cardiac arrest[18,19,20,21]. These studies showed that intraoperative hyperglycaemia should be avoided as the risk of potential hypoxic episode is high during anaesthesia, especially in children, who have reduced oxygen reserve and high metabolic rate as compared to adults. Furthermore, elevated blood glucose concentration may lead to osmotic diuresis which in turn could lead to fluid imbalance and electrolyte loss. These and the evidence obtained from this study provide a strong case for not using glucose containing solutions intraoperatively for routine fluid maintenance and replacement in children. However, care must be taken not to extrapolate these results to include neonates, and especially preterm newborns, as the risk of hypoglycaemia in these age groups is much higher because of their low stores of glycogen and fat.

Conclusion

This study showed that lactated Ringer's solution alone is the appropriate fluid for intraoperative use in paediatric surgery because of its ability to maintain normal glucose concentration. However, we must emphasize that because our study did not include newborns and neonates, these results cannot be extrapolated to include these age groups.

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