

Tolerance of, and metabolic effects of, preoperative oral carbohydrate administration in children — a preliminary report

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Abstract

Background: The need for long preoperative fasting has been questioned. Recent data shows that intake of an oral carbohydrate-containing clear fluid prior to anaesthesia is safe and may have a positive impact on recovery and metabolic status and could improve glucose tolerance. Such solutions are routinely used in adults but not children. The aim of this study was to evaluate the safety, tolerance and influence of oral carbohydrate on selected metabolic parameters in children.

Methods: With ethics committee approval and parental informed consent, 20 children, aged 4–17 years, ASA status I or II, scheduled for abdominal or thoracic surgery were randomised either to Group 1 — receiving a 12.6% carbohydrate-containing drink (10 mL kg⁻¹ the evening before surgery and two hours before anaesthesia), or the control Group 2 — fasting. Serum glucose and insulin concentration were measured four times: before and after anaesthesia, in the evening after surgery, and the following morning. IGF-1 concentration was measured once, before surgery. Insulin resistance was assessed by the HOMA-IR equation.

Results: Oral carbohydrate solution was well tolerated and no adverse events were noted. Glucose concentrations were within the normal range in both groups. Insulin concentration did not show significant differences between groups, however before surgery it tended to be lower in Group 1. Insulin resistance after surgery was significantly higher in Group 2 (2.0 vs. 0.62, $P = 0.03$), also the increase in insulin resistance after operation was significant only in the control group ($P = 0.03$).

Conclusion: Oral carbohydrates are safe, well tolerated and do not cause any perioperative adverse events. They seem to improve postoperative metabolism by decreasing insulin resistance.

Key words: preoperative fasting, metabolism, children; preoperative carbohydrate, metabolism, insulin resistance

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In recent years, long preoperative fasting of patients undergoing elective surgical procedures has been questioned. According to the current guidelines, clear liquids are acceptable until 2 h before surgery [1]. This kind of management does not increase the risk of aspiration during anaesthesia in children and adults [2, 3]. Overnight fasting results in general malaise, hunger, thirst, anxiety and weakness [4]. Moreover, fasting decreases hepatic glycogen stores and enhances gluconeogenesis as well as insulin resistance. The surgical procedure itself induces the metabolic response of the body leading to the release of stress hormones and pro-inflammatory cytokines, which is associated with intra- and postoperative insulin resistance, hyperglycaemia and catabolism. Fasting for many hours prior to anaesthesia

can enhance this response and result in increased percentages of postoperative complications [5]. The preoperative administration of carbohydrates has beneficial effects on the metabolic response to stress, mainly by decreasing insulin resistance hence reducing the tendency to hyperglycaemia and decreasing catabolism [6]. At present, ready-to-use 12.6% solutions of carbohydrates are available, which also contain electrolytes, designed for oral preoperative supply. In adults, they are administered in the evening preceding the elective surgery (100 g of carbohydrates in 800 mL) and two hours before the initiation of surgery (50 g in 400 mL). In patients who cannot receive oral fluids, rapid intravenous infusions of 20% glucose are applied. In many centres, such a policy is a routine element of metabolic preparation for

elective surgical procedures in adult patients [7–9], which reduces postoperative insulin resistance and hyperglycaemia, improves protein metabolism and reduces postoperative loss of fat-free body mass [6, 10, 11]. Moreover, it results in shortened hospitalizations, improves muscle strength and reduces perioperative discomfort [6, 12, 13].

In the population of paediatric patients, metabolic preparation for surgery is not routinely used. Moreover, there are no studies assessing preoperative administration of carbohydrates in children. The metabolic response to stress in children can vary from the response in adults; however, the effects of preoperative use of carbohydrates in children should be beneficial.

The aim of the present study was to assess the safety, tolerance and effects of oral clear solutions of carbohydrates administered to children preoperatively on the selected metabolic parameters.

METHODS

This prospective, open, randomised study was carried out encompassing children before elective abdominal and thoracic surgeries. The study design was approved by the Ethics Committee of the Medical University of Warsaw and informed consent was obtained from parents. The following inclusion criteria were accepted: extensive abdominal or thoracic surgery, age > 1 year, ASA I or II, feasible oral supply before surgery. The exclusion criteria included: children < 1 year of age, surgeries shorter than 1 hour, emergency surgeries, metabolic, endocrine and oncologic diseases, corticosteroid therapy, and lack of parental informed consent.

The children included in the study were randomly assigned into one of two groups: Group 1 received 10 mL kg⁻¹ of 12.6% carbohydrate solution (preOp, Nutricia, Holland) in the evening preceding surgery and two hours before the initiation of anaesthesia. In Group 2 (control), standard fasting was applied. All the patients received multi-electrolyte fluids during surgery, and multi-electrolyte fluids with glucose, 1–2 mg kg⁻¹ min⁻¹ after surgery.

Serum glucose and insulin concentrations were determined in blood samples collected before the initiation of surgery, after its completion on the evening of the surgery day and the next morning. Concentrations of glucose were determined with the colorimetric method using the Vitros 5600 device (Ortho Clinical Diagnostics, USA) whereas concentrations of insulin were determined with hemiluminescence using the Immulite 2000XPi (Siemens, Germany). Insulin resistance was calculated based on the above determinations using homeostasis model assessment of insulin resistance (HOMA-IR) and the formula:

$$\text{insulin resistance} = \text{insulin concentration } (\mu\text{U mL}^{-1}) \times \text{glucose concentration } (\text{mg dL}^{-1}) / 405.$$

Additionally, concentrations of IGF-1 were determined in the blood from the first sample using the enzyme-linked immunosorbent assay (ELISA) and the Asys UVM340 device (Biochrom, Great Britain).

Moreover, tolerance to oral carbohydrate preparation and complications developing during anaesthesia were assessed in all patients.

Statistical analysis was performed using STATISTICA 5.1 PL (StatSoft, Tulsa, USA). Data was presented as a mean \pm SD, median and range. When assumptions for parametric tests were met, the Student's t test for dependent and independent variables was applied for comparison of groups. When the data did not meet the assumptions for parametric tests, the Mann-Whitney U test was used for independent samples and the Wilcoxon matched-pairs signed rank test for dependent samples. $P < 0.05$ was considered as significant.

RESULTS

The study included 20 children, 11 girls and 9 boys, aged 4–17 years. The groups were matched in terms of age, gender and duration of surgery (Table 1).

In both groups, concentrations of glucose determined at all samplings were within normal limits and did not show significant differences (the glucose concentration did not exceed 180 mg dL⁻¹). Likewise, concentrations of insulin in serum did not reveal significant differences. However, in the group receiving carbohydrates prior to surgery, a tendency to lower insulin concentrations was observed. In both groups, increased concentrations of insulin were found after surgery. Concentrations of IGF-1 were within normal limits in both groups (Table 2).

Insulin resistance in the group of children without carbohydrates was significantly higher compared to the group receiving preoperative carbohydrates (2.0 vs. 0.62, $P = 0.03$) (Table 3).

Assessing increased insulin resistance postoperatively in relation to baseline values it was demonstrated that a significant increase was observed only in children who did not receive carbohydrates ($P = 0.03$ vs. $P = 0.14$).

Oral carbohydrate preparations were well tolerated and no complications related to their use were observed. No vomiting or other adverse side effects were found. Moreover, there were no cases of aspiration.

Table 1. Characteristics of study groups (means \pm SD or n)

Group	Group 1	Group 2
Size (n)	10	10
Age (years)	10.33 \pm 5.17	9.45 \pm 5.11
Gender (female/male)	7/3	4/6
Duration of surgery (h)	3.00 \pm 0.28	2.82 \pm 0.32

Table 2. Concentrations of glucose, insulin and IGF-1 in studied groups (means \pm SD)

Group	Group 1 (n = 10)	Group 2 (n = 10)	P value
Preoperative glucose (mg dL ⁻¹)	84.8 \pm 11.43	81.0 \pm 10.25	0.44
Postoperative glucose (mg dL ⁻¹)	124.2 \pm 34.29	104.7 \pm 23.15	0.15
Evening glucose (mg dL ⁻¹)	111.4 \pm 16.01	101.0 \pm 28.64	0.33
Morning glucose (mg dL ⁻¹)	99.0 \pm 19.57	83.7 \pm 23.47	0.15
Preoperative insulin (μ U mL ⁻¹)	2.87 \pm 1.47	5.39 \pm 3.87	0.07
Postoperative insulin (μ U mL ⁻¹)	6.61 \pm 7.60	9.88 \pm 8.40	0.37
Evening insulin (μ U mL ⁻¹)	6.56 \pm 6.04	6.0 \pm 6.09	0.86
Morning insulin (μ U mL ⁻¹)	6.50 \pm 6.25	6.07 \pm 4.52	0.86
IGF-1 (ng mL ⁻¹)	296.01 \pm 165.15	238.83 \pm 136.40	0.42

Table 3. Insulin resistance (median and range)

	Group 1 (n = 10)	Group 2 (n = 10)	P value
HOMA-IR before surgery	0.41 (0.32–1.41)	0.69 (0.36–2.5)	0.14
HOMA-IR after surgery	0.62 (0.37–2.22)	2.0 (0.43–7.55)	0.03
HOMA-IR in the evening	0.66 (0.51–1.43)	0.69 (0.37–6.67)	0.96
HOMA-IR in the morning	0.44 (0.24–3.32)	1.55 (0.4–2.05)	0.66

HOMA-IR — *homeostatic measurement assessment-insulin resistance*

DISCUSSION

Our findings seem to confirm the observations in adults and reveal that preoperative supply of carbohydrates improves the metabolic response to stress by improving metabolism of carbohydrates and reducing insulin resistance in paediatric patients as well. We have demonstrated that preoperative supply of the ready-to-use carbohydrate solution is safe, well tolerated and does not increase the risk of aspiration during anaesthesia. According to Senayli et al. [14], the use of the ready-to-use solution of carbohydrates in children is safe and does alter pH of gastric contents compared to children fasting until surgery and receiving drinking water. There are no randomised studies regarding preoperative oral supply of carbohydrates in adults showing increased risks of aspiration-related complications [15]. On the contrary, compared to intravenous supply of glucose or fasting, preoperative oral supply of carbohydrate solution decreases the gastric residual volume [16].

Surgery induces stress and metabolic responses manifested in postoperative insulin resistance, hyperglycaemia and increased metabolism. Preoperative fasting reduces systemic reserves of glucose and enhances postoperative insulin resistance. Preoperative supply of carbohydrates reduces insulin resistance and exerts beneficial effects on metabolism of proteins [17]. We assessed the effects of the ready-to-use carbohydrate solution on metabolism of carbohydrates in children. Serum concentrations of glucose in both study groups did not show significant differences

either before or after surgery. The concentration of insulin before surgery in the group receiving carbohydrates revealed a decreasing trend. Similar results have been found in patients qualified for elective laparoscopic cholecystectomy who received oral solutions of carbohydrates [18]. Likewise, meta-analyses evaluating the effects of such a policy in adults showed decreases in insulin concentrations before surgery [19, 20]. This fact results from higher tissue sensitivity to insulin in patients receiving preoperative carbohydrates, as the supply of carbohydrates has been demonstrated to increase insulin sensitivity by about 50%, to reduce nitrogen losses with urine and to decrease degradation of organ proteins [17].

Insulin resistance develops in response to surgery. Its duration and severity depends on the extent of surgery and the risk of complications. It is well known that the action of stressogenic factors in the post-meal phase induces markedly weaker metabolic responses compared to with the fasting state [17]. Preoperative supply of carbohydrates switches the metabolic status to the post-meal phase, restores the glycogen reserves and reduces the response to stress.

Our findings regarding insulin resistance in children are consistent with the results in adults, in whom preoperative supply of carbohydrates was found to decrease postoperative insulin resistance [15, 17, 19, 20]. Moreover, the above policy in adults exerts a number of beneficial clinical effects, i.e. improves the general physical and mental state of patients, reduces the incidence of postoperative vomiting, shortens hospitalizations, especially after extensive abdominal surgical procedures, accelerates the return of peristalsis after surgery and improves the muscular strength by inhibiting muscular mass [20].

At present, it is believed that the most means of assessing insulin resistance and insulin sensitivity is the hyperinsulinaemic normoglycaemic clamp technique, which allows detection of the smallest changes; the method is however relatively intricate. It involves continuous infusion of insulin and glucose enabling the maintenance of constant blood

insulin and glucose concentrations and very frequent determinations of glucose concentrations. The method used in the present study, i.e. HOMA-IR, is simpler, more widely used and reliable. The limitation of our study was the small number of patients in both groups analysed.

CONCLUSIONS

1. Preoperative oral supply of carbohydrate preparations in children is well tolerated and is not associated with increased risks of complications during anaesthesia; moreover, it improves postoperative metabolism of glucose by reducing insulin resistance.
2. Preoperative use of carbohydrate preparations in children has beneficial effects similar to those observed in adults.

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