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Original Research Article

Effect of Preoperative Oral Carbohydrate Loading on Hemodynamic Stability during General Anesthesia

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Abstract

Background: These factors along with long preoperative fast period may lead to thirst, relative intravascular depletion, metabolic stress, and exaggerated blood-pressure decrease upon induction of general anesthesia. Increased carbohydrate loading is known to be a part of the enhanced recovery program, but there is less of a clear association with early intraoperative hemodynamic stability. The aim of this study was to see if a pre-operative carbohydrate drink will decrease post induction hypotension and vasopressor use in adult elective laparoscopic abdominal surgery.

Methods: A prospective randomized study, 126 non-diabetic adults with American Society of Anesthesiologists physical status I-II were randomly divided into two groups: carbohydrate group (CHO) and conventional fasting group (FAST). The CHO group was given a 12.5% maltodextrin drink the evening before surgery and 2 hours prior to induction, while the FAST group was given a normal overnight fasting. Standardisation of anaesthetic technique, ventilation, fluid and vasopressor rescue levels. The main outcome was the induction hypotension, which was defined as mean arterial pressure (MAP) <65 mmHg or the drop >20% from the baseline pressure in the first 15 minutes after induction.

Results: Post-induction hypotension was seen in 11 patients (17.5%) in the CHO group and 23 (36.5%) in the FAST group ($p=0.026$). Lowest MAP was higher with carbohydrate loading (69.8 ± 8.7 vs. 64.2 ± 9.4 mmHg; $p=0.001$), and the maximal percentage fall in MAP was smaller (19.3 ± 8.1% vs. 26.8 ± 10.4%; $p<0.001$). Vasopressor therapy was necessary in 22.2% compared to 41.3% ($p=0.035$). Pre-induction Glucose was greater in CHO group and Postoperative was similar. The carbohydrate intake resulted in significantly reduced hunger and thirst scores. Regurgitation and/or pulmonary aspiration were not observed.

Conclusion: Oral carbohydrate loading prior to surgery had a beneficial effect on early haemodynamic stability and reduced the amount of vasopressors used during standardized general anaesthetic in selected non-diabetic elective surgical patients.

Keywords: Preoperative Fasting; Carbohydrate Loading; General Anesthesia; Hypotension; Mean Arterial Pressure; Enhanced Recovery After Surgery.

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Introduction

Fasting before surgery was established to minimize the chances of regurgitations and aspiration during surgical anesthesia. Modern directions for fasting, however, differentiate solid food from clear liquids and allow the appropriately selected healthy patient to ingest clear liquids at least until the time of induction for anesthesia. It is important to note that the use of carbohydrate-containing clear liquids (CCCL) is specifically recommended by the 2023 American Society of Anesthesiologists (ASA) guideline and is appropriate in an elective patient who meets the criteria for aspiration risk [1].

The progression is a result of a general trend to prevent the patient experience and physiological effects of unnecessarily prolonged fasting. The neuroendocrine stress response is affected by fasting before surgery. Surgery can worsen the catabolic state through depletion of hepatic glycogen, increased lipolysis, thirst, anxiety and decreased insulin sensitivity.

In fact, carbohydrate loading before elective surgery, using oral carbohydrate, has been shown to reduce the insulin resistance following the surgery in a foundation metabolic study [2]. Previous studies demonstrated that, compared to fasting and non-carbohydrate placebo, pre-operative carbohydrate treatment is more effective in maintaining insulin sensitivity [3]. Metabolic effect is seen immediately after surgery. Soop et al demonstrated that a carbohydrate-based drink before THR resulted in a lesser decrease of the insulin sensitivity of whole body compared with placebo [4]. In addition to metabolism, oral carbohydrate drinks can enhance the peroperative experience. In an elective surgical patient randomized study, Hausel et al. reported reduced hunger, thirst, anxiety and overall discomfort without any worsening of gastric fluid characteristics [5]. In the later trial, performed during the laparoscopic cholecystectomy, it was also suggested that preoperative carbohydrate treatment can also decrease the incidence of nausea in a part of the post-operative period [6].

Some of these findings have been supported with systematic evidence and uncertainty has been highlighted. In the context of elective surgery, carbohydrate loading has been demonstrated to be relatively safe, and could have beneficial effects on metabolic indices, although the magnitude of benefit is dependent on the surgery and the loading protocol [7]. As a result, the use of carbohydrates has become part of a multimodal enhanced recovery pathway and is not a single intervention that is likely to impact on all postoperative outcomes [8].

The immediate cardiovascular effect of induction of general anesthesia is relatively unexplored. Hypotension may occur precipitously in patients who arrive in the operating room after periods of time with inadequate fluid intake, and may be precipitated by propofol, volatile anesthetics, positive pressure ventilation and reduced sympathetic tone. A carb-containing clear fluid might theoretically help stabilize intra-vascular volume before induction, alleviate fasting related stress and dampen the magnitude of blood pressure drop after induction. Much of the studies on carbohydrate loading have been done, though, with a primary interest in insulin resistance, gastric emptying, comfort, length of stay, or postoperative recovery, not in prospective definition of early hypotension as the primary outcome.

This study was therefore designed to compare the hemodynamic stability between those patients undergoing oral carbohydrate loading before induction and those patients who were fasted overnight. The main goal was to compare the incidence of hypotension within 15 minutes of induction. Other endpoints were lowest MAP, percent reduction in MAP, blood-pressure variability, requirement for vasopressors, perioperative glucose, patient comfort, postoperative N/V, and aspiration-related events.

Materials and Methods

Research Methods and Context: A prospective, parallel-group, randomized and outcome-assessor-blinded trial was planned in adults undergoing elective laparoscopy under general anesthesia in a tertiary hospital.

Eligibility Criteria: Patients were eligible for inclusion if they were ASA physical status I or II in the age range of 18-65 years and undergoing laparoscopic cholecystectomy, laparoscopic hernia repair or any elective laparoscopic abdominal surgery planned to last 45-150 minutes. To avoid bias, patients were excluded if they had diabetes mellitus, pregnancy, body mass index greater than 35 kg/m2, symptomatic gastroesophageal reflux, a documented gastroparesis, bowel obstruction, severe renal or hepatic disease, heart failure, autonomic neuropathy, use of vasoactive medication other than stable antihypertensive therapy, anticipated difficult airway requiring an altered induction strategy, or failure to drink the assigned beverage within the time frame.

A sample size and allocation of samples are referred to as: The sample size was determined on the assumption that, after induction, the incidence of hypotension would drop from about 38% to 18%, respectively, in the conventionally fasted and carbohydrate loaded groups. A two-sided alpha of 0.05 and 80% power resulted in a sample size of 57 participants per group and 63 participants per group were enrolled for attrition. A random sequence generated on a computer, with variable block sizes, was embedded in a series of sealed opaque envelopes. The investigator recording postoperative outcomes and the statistician were blinded, and the anesthesiologist had to know if the patient had consumed the study drink.

Preoperative Intervention: All patients ate a light evening meal at a standard time (22:00). The CHO group was given 800 mL of a clear 12.5% maltodextrin drink between 21:00 and 23:00 and 400 mL 2 hours prior to scheduled induction time. The beverage contained about 50 g of carbohydrates and no fat, fiber or particulate matter in the morning dose. The local protocol was followed and the FAST group was instructed to avoid solid food starting from 22:00 and any caloric beverages after midnight. Small sips of water were allowed for essential oral medication.

Anesthesia Protocol: Patients were transported to the operating room and placed in the supine position for 5 minutes and then had three readings of HR and BP taken each minute, and their averages used as the baseline. Standard monitoring included electrocardiography, pulse oximetry, non-invasive blood pressure cycling every minute for the first 15 minutes post induction and cyclingly every 3 minutes thereafter, capnography, and neuromuscular monitoring. There was no preinduction fluid bolus. Fentanyl 1.5µg/kg was used for the induction of general anaesthesia, which was completed with volume-controlled ventilation and sevoflurane at the age adjusted minimum alveolar concentration of 0.8-1.0. Balanced crystalloid was given within the initial 1 hour at a rate of 4 mL/kg/h.

Hemodynamic Management: Post-induction hypotension was defined a priori as a MAP value <65 mmHg or a reduction > 20% from the pre-induction value at any point within 15 minutes of induction. A hypotenstive episode confirmed adequate anesthetic depth and mechanical factors, then a 100 mL crystalloid bolus and norepinephrine (NE) 5 µg of intravenous (IV) norepinephrine was administered if MAP did not reach the threshold for greater than 60 seconds. 5-µg doses could be repeated every 2 minutes. Atropine 0.6 mg was used to treat Bradycardia < 50 beats/min and hypotension. Vasopressor doses as well as all hemodynamic parameters were recorded on the anesthesia record.

Assessment of metabolic and comfort parameters.

Capillary glucose was taken just prior to induction and 60 minutes upon entry into post anesthesia care unit. Thirst and hunger were assessed on a 0 (no thirst/hunger) to 10 (very thirsty/very hungry) numeric scale just prior to transfer to the operating room. First 24-hours were the time frame used to assess nausea and vomiting. Regurgitation, suspected aspiration, unexpected oxygen requirement and pulmonary event after surgery were documented if present. Patients with diabetes were not included in the study protocol as the primary goal was to exclude the hemodynamic effects of diabetes in a lower risk population for aspirations and glycemia.

Outcomes: The main study end point was the number of patients who developed post-induction hypotension within 15 minutes. Secondary hemodynamic endpoints included lowest MAP, maximum percentage decrease from baseline, coefficient of variation of MAP over the first 15 minutes, number of hypotensive measurements, total norepinephrine administered, and treatment of bradycardia. Other endpoints were blood glucose, thirst, hunger, postoperative nausea or vomiting, and aspiration-related events.

Statistical Analysis: The data were presented as either mean ± SD for continuous or n (%) for categorical data. Independent-samples t tests were used to evaluate differences between groups for continuous variables when they were approximately normally distributed. Chi-square or Fisher exact tests were used for categorical variables. A linear mixed-effects model with fixed effects for group, time, and group-by-time interaction was also used to analyze the serial MAP measurements. The p value was considered to be statistically significant if <0.05 on both sides. Absolute risk reduction (RRR) and number needed to treat (NNT) were computed for the primary outcome.

Results

A total of 126 patients completed randomization and analysis, with 63 patients in each group. Baseline demographic characteristics, ASA status, baseline MAP, baseline heart rate, type of laparoscopic procedure, and duration of surgery were similar between groups (Table 1). The morning carbohydrate beverage was consumed 118 ± 16 minutes before induction. No patient in the CHO group reported intolerance sufficient to cancel or delay surgery.

The primary outcome favored carbohydrate loading. Post-induction hypotension occurred in 11 of 63 patients (17.5%) in the CHO group compared with 23 of 63 (36.5%) in the FAST group (p=0.026), corresponding to an absolute risk reduction of 19.0 percentage points and a number needed to treat of approximately 6. The lowest MAP during the first 15 minutes was higher in the CHO group (69.8 ± 8.7 vs. 64.2 ± 9.4 mmHg; p=0.001), and the maximal percentage reduction from baseline was smaller (19.3 ± 8.1% vs. 26.8 ± 10.4%; p<0.001). MAP variability was also lower after carbohydrate loading (Table 2). Rescue norepinephrine was required in 14 patients (22.2%) in the CHO group and 26 (41.3%) in the FAST group (p=0.035). Among patients who required vasopressor treatment, cumulative norepinephrine dose remained lower in the CHO group (8.6 ± 4.1 vs. 12.9 ± 6.2 µg; p=0.018). Bradycardia requiring atropine was uncommon and did not differ significantly between groups. The mixed-effects model demonstrated a significant group-by-time interaction for MAP during the first 10 minutes after induction, with the largest separation occurring at 2-5 minutes. Pre-induction capillary glucose was higher after carbohydrate loading (111.4 ± 14.2 vs. 92.1 ± 11.8 mg/dL; p<0.001), but postoperative glucose values were comparable (126.8 ± 18.4 vs. 129.2 ± 19.7 mg/dL; p=0.48). Thirst and hunger scores were substantially lower in the CHO group (Table 3). Postoperative nausea or vomiting occurred in 12 patients (19.0%) with carbohydrate loading and 21 (33.3%) after fasting, a difference that did not reach statistical significance (p=0.104). No episode of visible regurgitation, pulmonary aspiration, or unplanned postoperative ventilation occurred.

Table 1: Baseline characteristics

Variable	CHO group (n=63)	FAST group (n=63)	p-value
Age (years)	42.7 ± 11.1	43.5 ± 10.8	0.68
Male sex	31 (49.2)	29 (46.0)	0.72
BMI (kg/m²)	25.6 ± 3.1	25.9 ± 3.4	0.61
ASA I / II	40 / 23	38 / 25	0.72
Baseline MAP (mmHg)	92.4 ± 9.6	93.1 ± 10.1	0.69
Baseline heart rate (beats/min)	76.8 ± 10.5	77.9 ± 11.1	0.57
Duration of surgery (min)	78.9 ± 22.8	81.4 ± 24.1	0.55

Values are presented as mean ± SD or n (%), unless otherwise stated.

Table 2: Intraoperative hemodynamic outcomes

Outcome	CHO group	FAST group	p-value
Post-induction hypotension	11 (17.5)	23 (36.5)	0.026
Lowest MAP (mmHg)	69.8 ± 8.7	64.2 ± 9.4	0.001
Maximum MAP decrease (%)	19.3 ± 8.1	26.8 ± 10.4	<0.001
MAP coefficient of variation (%)	8.9 ± 3.5	12.1 ± 4.3	<0.001
Any norepinephrine rescue	14 (22.2)	26 (41.3)	0.035
Norepinephrine dose among treated (µg)	8.6 ± 4.1	12.9 ± 6.2	0.018
Atropine for bradycardia	3 (4.8)	6 (9.5)	0.49

Values are presented as mean ± SD or n (%), unless otherwise stated.

Table 3: Metabolic, comfort, and safety outcomes

Outcome	CHO group	FAST group	p-value
Pre-induction glucose (mg/dL)	111.4 ± 14.2	92.1 ± 11.8	<0.001
PACU glucose (mg/dL)	126.8 ± 18.4	129.2 ± 19.7	0.48
Preoperative thirst score (0-10)	2.1 ± 1.3	5.8 ± 1.7	<0.001
Preoperative hunger score (0-10)	2.5 ± 1.5	6.2 ± 1.8	<0.001
PONV within 24 h	12 (19.0)	21 (33.3)	0.104
Visible regurgitation	0	0	—
Pulmonary aspiration	0	0	—

Values are presented as mean ± SD or n (%), unless otherwise stated.

Discussion

Based on this randomized study, the authors conclude that the use of oral carbohydrate loading prior to induction of general anesthesia can have an immediate hemodynamic effect in well-selected non-diabetic elective surgical patients. Post-induction hypotension rates were reduced by about half, the lowest observed MAP was higher, the decrease in MAP was less, and there were fewer patients who needed norepinephrine.

These findings were seen even with a standard anaesthetic technique and without an oral 'bolus' of fluid prior to induction of anaesthetic, making a contribution made by the oral intervention more easily identified.

There are a number of physiological explanations. Overnight fasts can lead to thirst and a mild decrease in effective circulating volume with conventional fasts, or a decrease in systemic vascular resistance and venous return with induction using propofol. A clear carbohydrate drink given two hours before anesthetic induction provides hydration and substrate, thereby possibly enhancing pre-induction hydration and decreasing the neuroendocrine response to fasting. Results have been consistently demonstrated in the clinical literature in terms of comfort and metabolic response, but not always in terms of hemodynamic response. Bilku et al. did a literature search of randomized evidence and found that carbohydrate loading prior to surgery positively affects multiple parameters of insulin resistance and patient well-being, but did not see any clear signals of aspiration in the right set of patients [9].

It is crucial that the short fasting interval is safe for interpretation. In ambulatory surgical patients, Zhang et al. used bedside ultrasound and determined that gastric variables returned to baseline levels at 2 hours following a 200 mL carbohydrate beverage without regurgitation or aspiration [10]. Cho et al. later showed that gastric antral measurements in patients who were not fasted but were given carbohydrate drinks before elective laparoscopic gynecologic surgery were also noninferior [11]. The lack of regurgitation or aspiration is therefore in line with the available physiological and clinical evidence, but a study in 126 subjects does not prove safety for rare events of aspiration. There is a broader and more heterogeneous range of evidence. In a network meta-analysis of carbohydrate loading and prolonged fasting for elective abdominal surgery, Ricci et al. concluded that both carbohydrate-loading and clear water ingestion were superior to prolonged fasting for a number of outcomes, and that carbohydrate-related interventions were superior for metabolic measures and length of stay [12]. A second Bayesian network meta-analysis by Tong et al. also indicated potential effects on insulin-resistance outcomes but noted high levels of uncertainty at both the study-level and dose-level [13]. This heterogeneity is significant in that it is the opposite of what would suggest that loading carbohydrates in all patient populations would be a universal practice.

Our metabolic results support that alerting statement. As expected, pre-induction glucose was higher after the maltodextrin drink but there were no differences between groups in post-induction glucose. Diabetes and known gastroparesis were not included in the study. Diabetic patients with type 2 diabetes are more complex: Lee et al. found more hyperglycaemic variability and insulin resistance following a carbohydrate drink in diabetic patients undergoing joint arthroplasty, although there was no significant difference in gastric volume [14]. Therefore, the hemodynamic advantage proposed in the present study cannot be generalized to the different diabetes types without a specific evaluation and controlling of glycemic parameters.

Recent studies in diabetic and non-diabetic patients have also demonstrated that preoperatively carbohydrate intake 2 hours prior to surgery does not increase measured gastric volume, however, may result in a short-term rise in glucose concentrations in diabetes.

The results confirm the principle that there are two types of risk: aspiration and metabolic. There is no single universal rule for patients to fast and it is important to consider factors such as symptoms of delayed gastric emptying, gastrointestinal obstruction, severe reflux, autonomic neuropathy, medication effects, and the surgical context when selecting patients for fasting.

The hemodynamic changes are of clinical significance. In this model population, 19 percentage points of absolute reduction is equivalent to a number needed to treat of ~6. Short periods of intraoperative hypotension are also a problem, as these may affect the extent of organ perfusion and there is indication that the severity and duration of hypotension can be a concern in older and comorbid patients. This current research did not include outcome analysis of postoperative renal, cardiac or neurological disease and so cannot account for the possibility of less organ damage. However, less vasopressor use and more stable blood pressure following induction are important process outcomes in the peri-operative period. There are a number of restrictions to be noted. Firstly, the single center design and exclusion of higher-risk patients restrict the generalisability of the findings. Second, it was not possible to blind the clinicians, who might have affected subtle induction or timing of vasopressors, despite predefining the objective pressure threshold. Third, blood pressure may fluctuate quickly during the minute and these non-invasive measurements may miss these changes. Fourth, gastric volume was not measured immediately prior to induction, plasma insulin, osmolality or formal markers of intravascular volume were not measured, and thus the mechanism of improved stability can only be inferred. Lastly, only one formulation of maltodextrin was tested and only one regimen of timing. Patients should be stratified by age, baseline antihypertensive therapy, type of procedure, frailty, metabolic status, and trials should incorporate continuous non-invasive or invasive blood pressure monitoring; and determine if decrease in hypotension after induction results in measurable changes in organ-injury markers or quality of recovery. Comparative arms using only clear water would also allow separation of the effect of fluid volume from the specific metabolic effect of carbohydrate.

Conclusion

In selected non-diabetic adults undergoing elective laparoscopic surgery, preoperative oral carbohydrate loading was associated with fewer episodes of post-induction hypotension, a smaller decline in mean arterial pressure, and reduced vasopressor requirement compared with conventional overnight fasting. It also improved preoperative thirst and hunger without observed aspiration-related events. Carbohydrate loading may therefore support hemodynamic stability as part of an evidence-based enhanced recovery pathway, provided that aspiration risk and metabolic status are assessed individually.

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