CARBOHYDRATE LOADING AS AN ENHANCED RECOVERY AFTER SURGERY (ERAS) PROTOCOL FOR ABDOMINAL SURGERY

by

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CARBOHYDRATE LOADING AS AN ENHANCED RECOVERY AFTER SURGERY

(ERAS) PROTOCOL FOR ABDOMINAL SURGERY

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Abstract

Background Carbohydrate loading is a main component included in many ERAS protocols to attenuate the body's metabolic stress response during surgery. There are several different doses of carbohydrates and times of administration of the carbohydrate drink currently in practice.

Objectives Scoping review evaluating the dosing and administration of carbohydrate drinks prior to abdominal surgery.

Search methods Search conducted in Cochrane Library, PubMed, CINAHL Complete, Medline Complete, and Joanna Briggs Institute.

Selection criteria Systematic reviews, randomized controlled trials, quasi-experimental studies, and retrospective observational studies available in full text, English language, published between January 2002 and December 2022, peer reviewed, and only human subjects. All studies had to include dose of carbohydrates.

Data collection and analysis 27 studies found that matched with inclusion criteria. Studies were reviewed, placed into a table, and synthesized.

Main results Most common carbohydrate dose was a morning dose of 400 mL 2 hours prior to induction of anesthesia. 400 mL 2-3 hours or 3 hours prior to induction of anesthesia was also common. Positive results showing attenuation of the metabolic stress response were seen over multiple doses and times, showing it can be advantageous to provide any level of carbohydrates prior to surgery.

Authors' conclusions Carbohydrate loading is a safe, feasible, and effective implementation to improve the comfort of patients and attenuate the metabolic response during surgery.

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Introduction

Enhanced Recovery After Surgery (ERAS) protocols have become increasingly common in the surgical setting over the past two decades. ERAS guidelines are designed to have benefits including reductions in perioperative stress, maintenance of postoperative physiological function, accelerated recovery after surgery, reduction in the rate of morbidity, and shortened length of stay (LOS) (Gustafsson et al., 2019). Several key principles of preoperative ERAS include pre-surgical counseling, carbohydrate (CHO) loading, and the elimination of prolonged fasting. Intraoperatively, ERAS protocols regularly encourage the use of short-acting anesthetic agents, limited use of drains, and maintenance of normothermia. Other ERAS interventions include early mobilization, early removal of catheters, early oral or enteral nutrition, and non-opioid oral analgesic use (Melnyk et al., 2011). These protocols work to create better outcomes for patients post-surgery for a range of conditions and surgical procedures.

Preoperative CHO loading is one of the main nutritional interventions included in the ERAS protocol that is implemented to optimize recovery and lower the body's stress response. CHO loading is broadly defined as drinking a clear high carbohydrate drink 2-3 hours before induction of anesthesia. The premise of preoperative CHO loading is to create a meal response in the patient before surgery to improve the body's glycemic control (have the body in a "fed" state) during the operation. This reduces the stress response to surgery to improve patient outcomes, including increased patient comfort, shortened LOS, improved wound healing, and faster recovery of body systems (Burch, 2016). Additionally, ERAS protocols can be difficult to gain full compliance with because healthcare providers may believe they have already adopted ERAS into their practices (Brindle et al., 2019). As a singular protocol from ERAS, CHO loading can be adapted to fit the pediatric population. However, a gap in research exists regarding the importance of the implementation of ERAS within the discipline of pediatric oncology and it is not currently as widely accepted as necessary to be able to successfully apply it to the population in question.

This scoping review focused on CHO loading in adult patients undergoing abdominal surgery to show the benefits of CHO loading in adults that can then be more broadly applied to the pediatric population in the future. By synthesizing our findings for the dosing of CHO loading for abdominal surgery, we hope to gain standardization of dosage and reach a desirable level of compliance with CHO loading protocols.

Guiding Framework

Surgery and the Stress Response

The stress response during surgery involves changes in several body systems, including the endocrine system, which causes a range of negative effects. The endocrine and metabolic changes include insulin resistance, which can result in hyperglycemia and poor insulin control (Burch, 2016). The stress response also causes nitrogen loss, lipolysis, and a systemic release of cytokines which increase inflammation across the body (Fawcett & Ljungvist, 2017). These responses are detrimental to the patient's perioperative course and wound healing.

During surgery, the body shifts from anabolic to catabolic metabolism when it enters a state of insulin resistance (Fawcett & Ljungvist, 2017). This shift in metabolism causes the body to use stores of proteins, fats, and carbohydrates to keep the body healthy, with major impacts on the liver and the muscle. Since insulin resistance reduces the body's energy supply and increases the breakdown of proteins, it causes muscle breakdown. This muscle breakdown reduces glucose uptake in the muscle as well as glycogen storage, causing weakness and more challenges with movement and mobilization post-surgery (Fawcett & Ljungvist, 2017). In the liver, hepatic insulin resistance causes elevated plasma glucose concentrations, which can have significant impacts on patient outcomes including increased length of stay, infection rates, myocardial infarction, and renal failure, and is a contributor to death (Fawcett & Ljungvist, 2017).

Major surgeries, like abdominal surgery, result in the largest increase in insulin resistance, and the insulin resistance may last weeks. However, any surgical procedure causes dramatic drops in insulin sensitivity that can continue for up to three weeks (Pillinger et al., 2018). The inflammatory release of cytokines during the stress response, including interleukin-1 (IL-1), tumor necrosis factor (TNF), and interleukin-6 (IL-6) reduces immune function and delays wound healing (Pillinger et al., 2018). The amount of IL-6 released has been shown to correlate positively with the magnitude and duration of surgery. Additionally, oncology patients have an amplified stress response because they already enter surgery in an atypical metabolic state (Ackerman et al., 2020). Attenuating the impact and severity of insulin resistance as well as the surgical stress response is important to improving surgical outcomes.

Carbohydrate Loading as an ERAS Intervention

Prolonged fasting was found to cause discomfort to the patient and increases the stress response in the body (Fawcett & Ljungvist, 2017). Pillinger et al. (2018) notes that "the fed state is metabolically superior in the face of stress, including surgery and its attendant catabolic processes". Preoperative CHO loading aims to create the fed state and is meant to decrease the negative metabolic and inflammatory processes to improve outcomes post-surgery (Pillinger et al., 2018). There are several benefits to CHO loading. A significant benefit is that preoperative CHO loading creates better control of glucose, causing decreased insulin resistance which can then decrease the overall stress response (Ackerman et al., 2020). CHO loading also preserves muscle mass and prevents protein catabolism, which can positively affect the impact of surgery on muscle strength (Fawcett & Ljungvist, 2017). Attenuating muscle weakness post-surgical procedure can benefit the patient in many ways, namely by aiding in the prevention of immobility, which can lead to negative health outcomes. Another important benefit is that CHO loading also improves patient comfort and well-being (Fawcett & Ljungvist, 2017). Thirst, hunger, tiredness, malaise, anxiety, and mouth dryness are reduced when oral CHO loading occurs, and patients can also experience a decrease in nausea and vomiting. In their analysis of over 900 patients, Fawcett and Ljungvist (2017) reported CHO loading reduced feelings of nausea, dizziness, vomiting, and pain by 44% and decreased the risk of wound dehiscence. Pain and bedrest are contributors to perioperative insulin sensitivity (Pillinger et al., 2018). Additionally, decreasing weakness and discomfort in patients post-surgery can greatly impact recovery and improve patient outcomes. In colorectal surgery, muscle mass is maintained better with CHO loading implementation and increased compliance with ERAS protocol amplified the benefits (Ackerman et al., 2020).

Due to the effectiveness of CHO loading, it has expanded beyond general surgery and has been widely adopted into ERAS protocols for a range of major surgical procedures. Typically, there are two doses of a clear carbohydrate drink provided to patients in ERAS protocol. The evening dose works to build hepatic storage of carbohydrates but does not preserve insulin sensitivity for the surgical procedure (Pillinger et al., 2018). The morning dose of the CHO drink, however, works to create a meal response in the patient and minimizes insulin resistance (Pillinger et al., 2018). The specific doses of the drink and times vary between hospital protocols and will be examined in the scoping review of the literature.

Safety of Carbohydrate Loading

The intervention of preoperative CHO loading works to help lower the body's stress response and mitigate some of the negative effects resulting from the body's stress response during surgery. However, a common point of concern for healthcare providers is the safety of the implementation of CHO loading before surgery. In the past, the standard of care before surgery was fasting beginning at midnight before the morning of the surgery to avoid aspiration. However, the standard of care has evolved.

In the past 20 years, prolonged fasting was found to be unnecessary and is no longer the standard protocol, with healthcare professionals across the world agreeing with clear fluids are allowed until two hours before induction of anesthesia and solids are allowed until six hours prior (Weimann et al., 2021). The intervention of CHO loading with a clear carbohydrate drink is considered safe because clear liquids have been proven to empty the stomach within 60-90 minutes (Weimann et al., 2021). The key is to administer a drink containing a complex carbohydrate that empties quickly from the stomach. Maltodextrin has been studied and reliably empties from the stomach within 90 minutes (Fawcett & Ljungvist, 2017). In adults, enteral intake of a carbohydrate drink with 800 mL the night before and 400 mL before induction of anesthesia does not increase the risk of aspiration during surgery (Weimann et al., 2021). There were no reports of pulmonary aspiration in either large meta-analyses or the estimated five million patients worldwide who have experienced CHO loading during ERAS implementation (Fawcett & Ljungvist, 2017). This data shows CHO loading is a safe and feasible implementation for patients and there is no greater risk of aspiration when patients are administered a clear carbohydrate drink. The safety of CHO loading as an ERAS protocol was also evaluated through the scoping review and literature search.

Methods

The scoping review aimed to find available information on CHO loading as an ERAS intervention. The primary objective of the review was to address the implementation of CHO loading in abdominal surgery. The secondary objectives are identifying the standard doses of CHO loading.

A comprehensive review of the literature search of the Cochrane Library, PubMed, CINAHL Complete, Medline Complete, and Joanna Briggs Institute with search terms specifically focused on CHO loading as an ERAS component in abdominal surgery was conducted in November 2022. Search terms for the November search included “Carbohydrate Loading AND Abdominal surgery”, “Carbohydrate load”, “Preoperative carbohydrate AND abdominal surgery”, and “Preoperative Carb”. Inclusion criteria were systematic reviews, randomized controlled trials, quasi-experimental studies, and retrospective observational studies. All studies had to be available in full text and English. All studies included had to be published between January 2002 and December 2022 (within the past 20 years due to the lack of definition of ERAS protocols before that time) and were all peer-reviewed. Only human subjects were included. Additionally, all studies had to include the amount, or dose, of carbohydrates used. Exclusion criteria involved no expert opinion studies, case studies, abstracts, or conference proceedings. All studies only implemented CHO loading to minimize confounding variables.

A preliminary search of the results was conducted by the researcher using inclusion and exclusion criteria. Preliminary results showed 286 results in PubMed, 1 result from the Cochrane Library, 124 results in CINAHL Complete, 2883 results in Medline Complete, and 1 result in Joannah Briggs Insitute (JBI). Articles were screened, and then a secondary search was then completed, consisting of reading the full text of the remaining articles (N=27). These articles are summarized in Table 1 (Appendix A), and were appraised using the JBI Critical Appraisal Tools and the Johns Hopkins Evidence Level and Quality Guide (Appendix B).

Results

Review of Literature

Since the morning dose of the carbohydrate drink is the dose that works to create the meal response, lower insulin resistance, and attenuate the stress response, studies are arranged in terms of the timing and amount of the morning dose, although other variables possibly impacting outcomes will be considered and explained.

500 mL Carbohydrate Dose 2-3 Hours Before Anesthesia

Tsutsumi et al. (2016) performed a randomized controlled trial (RCT) evaluating the preoperative carbohydrate's effect on minor surgeries. Adult patients (N = 24) were split into two groups, the ONS, or CHO group (n = 12), and the control group (n = 12). The CHO group received 500 mL of Arginaid Water (80kcal/100mL, 2g arginine/100mL, 18g CHO/100mL, 140mg phosphate/100mL, 0.8mg copper/100mL, 560-580mOsm/L) 2 hours before surgery. The control group fasted after 2100 the night before surgery but was allowed water throughout the fasting period. Using blood samples, the Visual Analog Scale (VAS), and the Patient Health Questionnaire (PHQ-9), the CHO (ONS) group showed significantly lower serum free fatty acid levels than the control group (n=479; 408, 610uEq/L) and (n=828; 729, 1004uEq/L) p = .002; respectively. Total ketone bodies were also lower in the ONS (n=40; 27,64 umol/L) than in the control group (n=119; 68, 440 umol/L; p = .037). Additionally, the preoperative VAS scores for anxiety, hunger, and thirst as well as the PHQ-9 scores were lower in the CHO group than the control group. These results suggest oral carbohydrates decrease the amount of lipid catabolism during surgery which attenuates the surgical stress response, and that CHO loading may improve patient well-being in minor surgeries.

A randomized controlled trial (RCT) concentrated on radical distal gastrectomy patients worked to evaluate the effects of oral CHO loading (Yang et al., 2012). The study contained a CHOD (CHO drink) group (n = 24) and a placebo group (n = 24). The CHO group ingested 500 mL of a CHO drink containing 10% carbohydrates 2-3 hours before induction of anesthesia over 20 minutes, while the placebo group received 500 mL of a placebo drink containing no CHO. Blood glucose (7.64 vs 9.32; p = .026) and insulin (16.72 vs 30.72; p = .034) were lower post-operatively in the CHO group compared to the placebo; respectively. Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) was significantly lower after surgery in the CHO group (5.67) vs placebo group (12.68; p = .003). Researchers found administration of preoperative oral CHO attenuated insulin resistance intraoperatively.

400 mL Carbohydrate Dose 90 minutes Before Anesthesia

One RCT focused on patients undergoing inguinal hernia repair (N = 44) under spinal anesthesia's response to oral CHO loading (Yagmurdur et al., 2011). The CHO group (n = 22) received 800 mL of Nutricia PreOp (12.5% carbohydrates, 50kcal/100mL, 290 mOsm/kg, pH 5.0) the night before the surgery and an additional 400 mL 90 minutes before induction of anesthesia, while the control group (n = 22) fasted beginning at midnight. In terms of well-being, the study found that the CHO group showed decreasing trends for discomfort variables of hunger using a VAS scale (40 minutes after intake CHO group 25 vs control group 61; 90 minutes after intake 22 vs 69; 60 minutes after spinal anesthesia 23 vs 75; p < .001), thirst (40 minutes after intake 21 vs 58; 90 minutes after intake 20 vs 60; 60 minutes after spinal anesthesia 18 vs 64; p < .001), and malaise (40 minutes after intake 10 vs 22; 90 minutes after intake 10 vs 21; 60

minutes after spinal anesthesia 8, 23; $p < .05$). Another variable defined as unfitness also showed decreases with CHO administration (40 minutes after intake 16 vs 32; 90 minutes after intake 17 vs 32; 60 minutes after spinal anesthesia 16 vs 30; $p < .01$) during the perioperative period, and the CHO group was also less anxious than the control group at 40 and 90 minutes post-ingestion of the morning drink (40 minutes after intake 21 vs 50; 90 minutes after intake 20 vs 48; 60 minutes after spinal anesthesia 43 vs 46; $p < .05$). Additionally, plasma glucose and insulin concentration were increased in the CHO group before anesthesia compared to the control group ($p < .05$) and MAP was lower in the control group at 10- and 20-minutes post-anesthesia (10 minutes post-anesthesia 98 vs 75; 20 minutes 100 vs 80; $p < .05$). The study results suggest oral CHO loading stabilized patients' MAP, reduced insulin resistance, and improved overall patient well-being.

400 mL Carbohydrate Dose 2 Hours Before Anesthesia

The effects of CHO on postoperative nausea and vomiting (PONV) post-laparoscopic cholecystectomy showed positive results in reducing patient discomfort with a 400 mL dose of CHO 2 hours before anesthesia (Hausel et al., 2005). The RCT completed in adults across three hospitals contained a CHO group ($n = 55$), a fasting group ($n = 58$), and a placebo group ($n = 59$). The CHO group received an 800 mL dose of Nutricia PreOp in the evening and 400 mL of Nutricia PreOp 2 hours before induction of anesthesia. Results for this study found that the incidence of PONV decreased significantly over time in CHO (0-4hr post-surgery PONV episodes n = 14, vomiting n = 3; 4-12hr PONV episodes n = 5, vomiting n = 0; 12-24hr PONV episodes n = 1, vomiting n = 0; $p < .001$) compared to the placebo group (0-4hr post-surgery PONV episodes n = 15, vomiting n = 1; 4-12hr PONV episodes n = 8, vomiting n = 3; 12-24hr PONV episodes n = 4, vomiting n = 1; $p = .006$). Additionally, none of the patients receiving

CHO vomited in the first four hours post-operatively in comparison to several patients in both the placebo and fasted groups. Overall, the study suggested a reduction in nausea and vomiting when the CHO drink was administered.

Kaska et al. (2010) studied the effect of CHO loading on elective colorectal surgery by using a CHO loading group (*n* = 74), fasting group (*n* = 75), and an IV glucose group (*n* = 72) in adult patients. This study intervention included oral administration of 400 mL of Nutricia PreOp the evening before surgery and another 400 mL dose of Nutricia PreOp 2 hours before anesthesia. Results showed the oral CHO group had the best psychosomatic conditions with significant reductions of thirst, hunger, anxiety, and pain using the Beck questionnaire ($p \leq .001$ preoperatively and $p \leq .029$ postoperatively), improved cardiac function through increased ejection fraction (oral CHO group 67.1, IV glucose group 65.7, fasting group 65; $p < .05$), and no increase in the risk of aspiration in the oral CHO group (normal gastric residual volume and pH). Hospital stay and rate of complications did not significantly differ. However, insulin serum concentration appeared physiological in the oral CHO group, informing a preserved insulin sensitivity with oral CHO. In addition to attenuated insulin resistance, C-reactive protein was lowest in the IV glucose group and oral CHO group (Day 0 fasting group 6, IV glucose group 2.00, oral CHO group 4.5. Day 1 fasting group 89.9, IV glucose group 83.2, oral CHO group 86.7; Day 3 fasting group 125, IV glucose group 108, oral CHO group 101; Day 7 fasting group 24, IV glucose group 29, oral CHO group 21.5). Findings showed the oral CHO group was found to have the lowest inflammatory response out of the three groups.

Lee et al. (2018) focused on the effect of CHO loading on patients undergoing laparoscopic cholecystectomy and their satisfaction and recovery post-surgery. Participants (*N* = 141) in this RCT were split into three groups. The CHO group (*n* = 46) received 400 mL of the

CHO drink (No-NPO; 12.8% CHO, 50 kcal/100 mL, 290 mOsm/kg) from 2000 to 2200 the night before surgery and another 400 mL dose 2 hours before anesthesia. The MN-NPO group (*n* = 51) fasted past midnight, and the placebo group (*n* = 44) received the same amount of fluid as the other two groups but received flavored water instead of No-NPO. Results showed a reduction in antiemetic consumption in the CHO and placebo groups, but it was not statistically significant (1] [2%] in the CHO group versus 4 [8%]) in the other two groups, *p* = .532). There were no significant differences between the placebo drink and the No-NPO beverage.

Lidder et al. (2013) studied the effect of carbohydrate drinks on insulin resistance, handgrip strength, pulmonary function, intestinal permeability, and postoperative complications in patients undergoing resection of colorectal cancer. Four groups were randomized, including a full CHO group (Group D; *n* = 27) who received 400 mL of Nutricia PreOp 2 hours prior and 600 mL of a polymeric nutritional supplement drink (Fortifresh; 150kcal/100mL, 965 mOsm/kg, pH 4.2) every day until discharge, two partial CHO groups (Group B; *n* = 32 and Group C; *n* = 31; respectively), one of which received 400 mL of Nutricia PreOp 2 hours before surgery and 600 mL of a placebo drink every day until discharge and another receiving 200 mL of a placebo drink 2 hours before discharge and 600 mL of Fortifresh every day until discharge, and the placebo group (Group A; *n* = 30) who received placebo drinks of both the 200 mL pre-surgery drink and the 600 mL after-surgery drink. Results showed HOMA-IR improved most in the full CHO group (*p* = .011). Patients in the full CHO group experienced fewer clinical complications (*n* = 15) than those in group A (total number of complications by postoperative day (POD) #5; partial CHO groups *n* = 17, and *n* = 20, and *n* = 20 in the placebo group; *p* = .003). Insulin tolerance tests (ITT) decreased in group B, which received Nutricia PreOp before surgery (*p* = .044), and the full CHO group (*p* < .001) compared with the placebo group, indicating preoperative carbohydrates help with insulin sensitivity. Peak expiratory flow rate improved in group B and group D compared with group A ($p = .002$ and $p = .035$). Overall, the findings in this study indicate that preoperative carbohydrates are beneficial to insulin sensitivity, improve handgrip strength, decrease insulin resistance, and aid in pulmonary function.

Mathur et al. (2010) evaluated preoperative CHO on LOS and fatigue in adult colorectal and liver resection patients. Patients were split into a CHO group ($n = 69$) or a placebo group ($n = 73$). The CHO group ingested 800 mL of Nutricia PreOp between 1900 and 2400 the night before surgery and then received a dose of 400 mL 2 hours before induction of anesthesia. The placebo group ingested the same amounts as the CHO group but instead drank flavored water. Water was allowed for both groups throughout the night. Results showed no significant differences in fatigue, glucose, insulin, and CRP. The median LOS was 7 days in the CHO group and 8 days in the placebo group ($p = .344$) and the fitness for discharge was also different (6 (2-35) and 7 (2-92) days respectively; $p = .523$), but not statistically significant. Cortisol concentration was significantly lower in the CHO group on POD 1 (POD0 416(27) vs 445(24); POD1 219(34) vs 473(44); POD3 495(40) vs 511(26); POD5 540(22) vs 524(33); POD7 575(36) vs 591(56); POD28 407(36) vs 417(25); $p < .001$), but no significant beneficial clinical effects were found in this study due to the lack of a homogenous patient group.

Another RCT focused on the outcome of insulin resistance when determining the effects of CHO loading (Qin et al., 2022). The study was performed in adults undergoing elective gastrectomy, colorectal resection, or duodeonopancreatectomy ($N = 223$). The intervention group ($n = 112$) received 800 mL of a 12.5% maltodextrin/fructose mixture solution (Suquian) 10 hours before the operation and another 400 mL 2 hours before the induction of anesthesia. The control group ($n = 111$) received the same amount of fluid, but only water. Results showed a significant difference in HOMA-IR between the intervention and control group (POD1 11.38 (16.11) vs 20.21 (42.27); POD3 7.19 (7.3) vs 14.91 (59.48); *p* = .02). The control group had significantly higher HOMA-IR, indicating higher insulin resistance. The CHO group experienced lower levels of anxiety (1.76 (1.71) vs 2.43 (2.44)), lower nausea (1.42 (1.67) vs 2.19 (2.81)), and a lowered appetite (2.04 (2.03) vs 2.15 (1.89)) preoperatively. LOS and time to passage of first flatus were also lower in the CHO group, but not statistically significant (11.29 vs 11.67; *p* = .6762; 3.29 vs 3.25; *p* = .7902; respectively). This study showed oral CHO administration attenuated insulin resistance when compared with a placebo for a range of abdominal surgeries.

Sada et al. (2014) focused on preoperative CHO loading for patients undergoing open colorectal surgery. The study was split into types of operation- either open abdominal cholecystectomy or open colorectal surgery- and each had a study group (*n* = 22), a placebo group (*n* = 23), or a control group (*n* = 26). The study group received 800 mL of Nutricia PreOp at 2200 the night before their operation and an additional 400 mL 2 hours before induction of anesthesia, while the placebo group received the same number of fluids in flavored water, and the control group fasted beginning at midnight. In the open cholecystectomy patients, there was a statistically significant difference compared to the control group in their degree of hunger (study group median 3, placebo 2, control 4), thirst (study group median 3, placebo 2, control 4), mouth dryness (study group median 5, placebo 4, control 6), nausea (study group median 1, placebo 3, control 2.5), and weakness (study group median 4, placebo 3, control 3) in the first 24 hours after surgery ($p < .05$). In the open colorectal surgery patients, thirst was significantly lower in the first 24 hours post-surgery (study group median 3, placebo 2, control 4; *p* = .027). Overall, this study showed an increase in patient comfort with the administration of the preoperative CHO drink.

Shi et al. (2020) evaluated the effect of oral CHO loading on open colorectal cancer patients, with a CHO group (*n* = 21), a fasting group (*n* = 21), and a placebo group (*n* = 21). At the end of the operation, blood glucose, blood insulin, and HOMA-IR were significantly lower in the CHO group than in the fasting and placebo groups (p < .05). Insulin sensitivity index (ISI) was significantly higher in the CHO group than in the fasting and placebo groups (*p* < .05). Additionally, phosphorylation of mTOR Ser244, S6K1, and IRS-1 were significantly lower in CHO group than fasting and placebo groups post-operatively. The level of phosphorylated AMPK was also significantly higher in the CHO group than in the other groups. This study found that preoperative oral CHO administration attenuated insulin resistance and lowered the inflammatory response in open colorectal resection.

An RCT completed reported the outcomes in laparoscopic cholecystectomy patients and CHO loading (Yilmaz et al., 2013). Group C (*n* = 20) ingested 400 mL of Nutricia PreOp 2 hours before surgery, with no PM dose, while group F (*n* = 20) fasted for 8 hours. Results found that anxiety was decreased in the CHO group, with higher pre-operative anxiety in group F (16.62 vs 24.38; *p* = .035), and patients who experienced CHO loading were generally considered more satisfied with their care (p < .001). Additionally, PONV was decreased in group C, with less antiemetic consumption than group F and lower Verbal Descriptive Scores (VDS) (drug 24hr 13,50 vs 27,50; *p* < .001; and 24hr VDS 13,02 vs 27,98; *p* = .001; respectively).

400 mL Carbohydrate Dose 2-3 Hours Before Anesthesia

Yildiz et al. (2013) performed a study on laparoscopic cholecystectomy patients, with a CHO group (*n* = 30) and a control group (*n* = 30). The CHO group received 800 mL of Nutricia

PreOp the night before their operation and 400 more mL 2-3 hours prior, while the control group experienced an 8-hour fasting period. The main positive outcome found was an increase in well-being through the VAS. Malaise (2 vs 10), thirst (4 vs 12), hunger (0 vs 11), and weakness (5 vs 13) were decreased in the CHO group in comparison to the control before surgery ($p = .024$), and decreased thirst (13 vs 30), hunger (5 vs 26), and weakness (5 vs 14) after the operation ($p < .05$), leading researchers to suggest CHO loading is safe and effective to increase well-being intraoperatively. Results show preoperative oral CHO loading can help increase patient well-being.

Yuill et al. (2004) focused on major elective upper-gastrointestinal surgery patients and a morning CHO loading dose of 400 mL. The CHO group ($n = 31$) received 800 mL of a CHO-rich drink (12.6g carbohydrates/100 ml with electrolytes; potassium, sodium, chloride, calcium, magnesium) the night before their operation about 12 hours prior and another dose of 400 mL 2-3 hours before induction of anesthesia ingested over 20 minutes. The placebo group ($n = 34$) received the same administration of fluids still containing the electrolytes but with no CHO (fluid and electrolytes; potassium, sodium, chloride, calcium, magnesium). Although it was not considered statistically significant, the median LOS in the CHO group was 8 days compared to 10 days in the placebo group. Loss of muscle mass was a statistically significant finding, with the loss being significantly greater in the placebo group (-0.5 cm vs -1.1 cm; $p < 0.05$). Researchers attested to the safety of administration and the attenuated muscle loss postoperatively after major abdominal surgery.

400 mL Carbohydrate Dose 2-3 Hours Before Anesthesia

One RCT compared a CHO group ($n = 16$), a CHO with peptides group (CHO-P; $n = 16$), and a fasting group allowed only water ($n = 16$) to see effects on postoperative comfort and muscle strength in elective bowel resection patients (Henriksen et al., 2003). The CHO group ingested two 400 mL doses of a CHO-rich drink containing 12.5g maltodextrin/100 mL. The first dose was just before sleeping the night before surgery and the second was 3 hours before the induction of anesthesia. Results showed concentrations of insulin in serum were lower in the fasting group compared to the two intervention groups before the operation (4hr CHO group 31, CHO-P 46, control 29; $p = .002$) and groups receiving beverages (the CHO and CHO-P group) had significantly better muscle strength compared with the control group (10-11% decrease in strength in CHO and CHO-P group vs 16% in the control group). Implications of this article show that receiving carbohydrates can help decrease the negative impact of surgery on muscle strength.

Noblett et al. (2006) studied the impact of CHO loading on grip strength, gastrointestinal function, and hospital stay after elective colorectal surgery. Patients in this study were broken up into three groups, including a CHO group (Group 2; $n = 10$), a placebo group (Group 1; $n = 11$), and a fasting group (Group 3; $n = 12$). The CHO group ingested 100g Precarb (96.0 g CHO /100g, 380 kcal/100g, 285 mOsm/100g) dissolved in 800 mL of water the night before surgery and 50g of Vitajoule dissolved in 400 mL of water 3 hours before induction of anesthesia. Findings for this study included earlier bowel movements seen in CHO group compared with those who fasted and those who drank water only ($p = .2$; $p = .06$; respectively). Most importantly, the median time to fitness to discharge was 10 days in the fasting group, the water group was 13 days, and in the CHO group 7.5 days, which shows a statistically significant difference in LOS between the CHO and water groups ($p = .019$). In this study, there was an earlier return to bowel function with the administration of preoperative carbohydrates and a significant difference in LOS.

A controlled prospective cohort study focused on elective abdominal surgery patients assessed the effect of preoperative CHO loading on the metabolic stress response (Vigano et al., 2012). An OCH (CHO) group (*n* = 38) received 800 mL of a carbohydrate-rich drink, Nutricia PreOp, between 1800 and 2400 the night before the operation and ingested another 400 mL 3 hours before anesthesia, while the control group (*n* = 38) fasted from midnight but was allowed water. Results showed that with preoperative oral CHO, there was a decrease in glucose and interleukin-6 (IL-6) levels (POD1 128 vs 186, $p < .001$; POD2 121 vs 144, $p = .001$ and POD1 20 vs 199, p < .001; POD2 15 vs 149, p < .001; respectively) and oral CHO was associated with lower rates of infection for major abdominal surgery patients (0 vs 5, $p = .054$). Additionally, patients who underwent oral CHO loading experienced lower increases in HOMA-IR, glucose levels, and cortisol on POD1 (4.8 vs 9.0, $p = .005$; 128 vs 186, $p < .001$; 23.4 vs 28.6, p = .044; respectively). No significant differences were seen in terms of LOS. Study findings supported that postoperative oral CHO loading is a safe intervention that can lower the metabolic stress response to surgery.

Wang et al. (2010) performed an RCT focused on insulin resistance with adult colorectal resection surgery patients. 48 patients were split between a OCH (CHO) group (*n* = 16), a placebo group (*n* = 16), and a fasting group (*n* = 16). The CHO group received 400 mL of Nutricia PreOp 3 hours before induction of anesthesia ingested over 1 hour. The placebo group received the same amount of fluid but in flavored water. The fasting group fasted overnight. Results found that median levels of HOMA-IR were significantly lower in the CHO group than in the other two groups at the end of surgery (CHO group median 17, placebo 25, fasting 27, $p < .001$), and median Insulin Sensitivity Index (ISI) for patients receiving CHO was significantly higher at the end of surgery compared to the other two groups ($p < .001$), which points towards a lowered insulin resistance with preoperative oral CHO. Additionally, for patient well-being, the VAS scores for thirst were decreased compared to the placebo (1-hour pre-op CHO group 20 (8-59), fasting group 34 (19-60), and placebo group 17 (6-53), *p* = .006) and the ratings for hunger were decreased in both the CHO and placebo group compared to the fasting (1-hour pre-op CHO group 18 (7-37), fasting group 28 (13-50), and placebo group 22 (9-37), *p* = .041). In this study, patients who received preoperative oral CHO loading experienced decreased insulin resistance and lower levels of hunger and thirst.

One RCT evaluated CHO loading on elective colorectal patients but focused on the outcome of postoperative walking capacity (Wongyingsinn et al., 2019). The CHO group (*n* = 30) received 800 mL of a CHO drink (12.5g carbohydrates/100mL, 80% maltodextrin, 20% glucose, 50kcal/100mL, 280mOsm/kg, pH 7.0, sodium 50mmol/100mL, potassium 122mmol/100mL, chloride 13.3mmol/100mL, calcium 6mmol/100mL, phosphorus 1mmol/100mL, magnesium 1mmol/100mL) between 1900 and 2400 the night before surgery and an additional 400 mL 3 hours before induction of anesthesia. The water group (*n* = 29) received the same amount of water at the same administration times. No statistically significant differences were observed in this study, but a shorter median duration of stay was observed (5.5 vs 6; *p* = .494). This study did not find statistically significant differences but supported the safety of the intervention.

400 mL Carbohydrate Dose Between 12-2 Hours Before Anesthesia

Bisgaard et al. (2004) studied the impact of CHO loading on laparoscopic cholecystectomies but gave patients a longer range of time to ingest the CHO drink. Patients were randomized into two groups, the CHO group (*n* = 43) and the placebo group (*n* = 43). However, the CHO group in this study received 800 mL of Nutricia PreOp between 2000 and

2400 the night before the operation, and then ingested 400 mL over 10 minutes from midnight up to 2 hours before induction of anesthesia, leaving a longer time frame for ingestion of the second dose. Results for this study showed no significant differences in LOS, well-being, pain, PONV, or sleep quality in patients who received CHO loading versus the placebo. However, the study supported the safety of the CHO-loading drink.

250 mL Carbohydrate Dose 2 Hours Before Anesthesia

One single center RCT focused on the impact of CHO loading on intraoperative core temperature (Hamamoto et al., 2018). This study looked at 65 adult patients undergoing laparoscopic colon cancer surgery, with a CHO group (n = 31) and a control group (n = 33). The CHO group consumed 500 mL of Arginaid Water the night before surgery and another 250 mL 2 hours before anesthesia. The control group was only allowed water after midnight. Results showed the core temperature of the CHO group was significantly lower 90, 120, and 150 minutes after surgery (90 min: 36.26 vs 36.05°C, p = .0233; 120 min: 36.30 vs 36.06°C, p = .0283; 150 min: 36.33 vs 36.01°C; p = .0186). There was also a significant difference in body weight loss and loss of lower limb muscle mass, with the CHO group having lower loss overall (-1.6 vs -0.9 kg, p = .0304; - 0.7 vs - 0.3 kg, p = .0110). The study showed that the CHO drink attenuated muscle loss during surgery and lowered intraoperative core temperature.

200 mL Carbohydrate Dose 2 Hours Before Anesthesia

One RCT studying laparoscopic cholecystectomy patients used 50g of maltodextrin (CHO group; n = 12) compared to a maltodextrin and glutamine group (GLN group; n = 12), a placebo group (n = 12), and a fasting group (n = 12) (Dock-Nascimento et al., 2011). All patients in this study (N = 55) were female. The CHO group was given 400 mL of water with 50g of maltodextrin 8 hours before anesthesia, and another 200 mL of water with 25g of maltodextrin 2 hours prior. Blood samples were collected throughout the perioperative period to evaluate insulin resistance and inflammatory cytokine levels. Results showed postoperative insulin resistance, measured by HOMA-IR, was higher in control patients compared with the CHO (2.3 [0.4]; p = .02), placebo (1.6 [0.3]; p = .03), and GLN (1.5 [0.1]; p = .01) groups. Those who received beverages also experienced decreases in their cortisol levels, with C-reactive protein (CRP)/albumin levels being higher in control patients compared to CHO and GLN group postoperatively (CHO 2.3, GLN 2.3, placebo 2.5, control 5.1, p = .02; CHO 4.1, GLN 4.1, placebo 3.7, control 4.1; respectively). This study supported the use of carbohydrate drinks and carbohydrate drinks containing glutamine to lessen the inflammatory response post-operatively.

Another study with all female laparoscopic cholecystectomy patients advocated for using preoperative oral CHO loading to attenuate insulin resistance (Ravanini et al., 2015). The study had a CHO group (n = 21) and a fasting group (n = 17). The CHO group drank 200 mL of a CHO and protein solution (Fresubin Jucy Drink; 150kcal/100mL, 4g protein/100mL, 33.5g CH/100mL, 0g lipids/100mL) 2 hours before the surgery and the fasting group fasted beginning at 2200 the night before the operation. The fasting group experienced higher levels of serum insulin and insulin resistance compared with the CHO group (-13.2% vs 10.4%, p = .01; 7.5% vs 38.7%, p = .001; respectively). This study found that oral CHO attenuated insulin resistance in laparoscopic cholecystectomy.

Helminen et al. (2019) completed an RCT measuring the impact of oral CHO on recovery in day-case cholecystectomy patients. The study divided participants into the CHO group (n = 53) and the fasting group (n = 53). This study included no PM dose, but the CHO group consumed 200 mL of Providextra (300 kcal, 67-g carbohydrate, 8g protein) before leaving for the hospital at either 0600 (2 hours before surgery) or 0800 for later surgeries. Results of this study showed no significant differences in well-being or recovery between the two groups but noticed that ingestion of the drink decreased VAS scores for thirst before the operation (22 vs 40) and caused no negative patient outcomes.

Risvanovic et al. (2019) performed an RCT of the effects of preoperative CHO loading for open radical resection of colorectal cancer. Patients were randomized into a CHO group (n = 25), or a control group (n = 25). The CHO group received 400 mL of a clear CHO drink (12.5g/100mL maltodextrin, 50kcal/100mL, pH 5.0) at 2200 the night before their operation and 200 mL 2 hours before induction of anesthesia. The control group fasted for 8 hours before the surgery. Overall, HOMA-IR and insulin was higher in the control group, and the total increase in HOMA-IR was 30% lower in the CHO group. There were also significantly greater CRP and IL-6 levels in the control group than the CHO group after surgery (CRP 6hr post-surgery 18.3 vs 52.7, p = .001; 06hr POD1 62.9 vs 52.7, p = .001; 06hr POD2 83.8 vs 125.3, p = .001; and IL-6 6hr post-surgery 123.7 vs 347.4, p = .001; 06hr POD1 48.4 vs 143.2, p = .001; 06hr POD2 19.9 vs 48.5; p = .001; respectively), suggesting a lower inflammatory response in the CHO group. Patient comfort was also higher in the CHO group, with VAS scores being significantly higher in the control group and a higher incidence of nausea after surgery ($p < .02$ and $p < .04$; respectively). This study demonstrated that preoperative oral CHO provided better insulin sensitivity, attenuated the inflammatory response to surgery, and enhanced patient comfort.

Singh et al. (2015) focused on preoperative oral CHO's impact on laparoscopic cholecystectomy. 120 adult male and female patients were split into groups of 40 participants. Group A, or the CHO group, received 400 mL of a clear carbohydrate-rich drink (12.5% carbohydrates, 50kcal/100mL, 290 mOsm/kg, pH 5.0) from 2000-2200 the night before surgery and an additional 200 mL at 0600 the morning of the operation, which is 2 hours before induction of anesthesia. Group B was a placebo group, receiving the same amount of liquid but only water, and group C fasted starting at midnight. VAS scores were collected perioperatively, and nursing staff recorded episodes of nausea and vomiting. There was a significant decrease in the incidence of nausea in 0-4hrs when the CHO group was compared with the placebo group (group A 52.5 % in 0–4 h, 55 % in 4–12 h, 25 % in 12–24 h after surgery; group B 87.5 % in 0–4 h, 67.5 % in 4–12 h and 42.5 % in 12–24 h after surgery; group C 80 % in 0–4 h, 75 % in 4–12 h and 53.8 % in 12–24 h after surgery; p = .0006). Additionally, the mean score of nausea in 0-4 h in the CHO group was significantly lower as compared to the placebo and fasting groups (group A mean number of nausea episodes 0.65, group B 1.30, group C 1.23; p = .001). For pain in VAS scores, the mean score of pain was significantly less in the CHO group at 0-4hrs (group A 5.75, group B 7.13, group C 6.95, p = .001) and 4-12hrs (group A 3.53, group B 4.08, group C 4.65, p = .005). Overall, researchers found CHO loading decreases instances of nausea, vomiting, and pain postoperatively for patients undergoing laparoscopic cholecystectomy.

200 mL Carbohydrate Dose 3 Hours Before Anesthesia

Webster et al. (2014) performed an RCT to evaluate changes to LOS in elective colorectal surgery patients, with a CHO group (n = 22) and a usual care group (n = 22). The CHO group received 800 mL of a CHO drink (50kcal/100mL, 290 mOsm/kg, pH 5.0) the night before surgery between 1900 and 2400, and an additional 200 mL at 0500 the day of the operation (around 3 hours prior) with other clear fluids allowed. The usual care group fasted beginning at midnight but was similarly allowed other clear fluids until 0500. Results were inconclusive, with no difference in the mean time to readiness to discharge (4.3 vs 4.1 days, p = .824), and no significant differences in time to the passage of first flatus and time to first bowel movement (34.7 vs 49.8 hours, p = .129; 46.5 vs 68.4 hours, p = .082; respectively) even though values were decreased in the oral CHO group. Overall, researchers found no significant differences.

Synthesis of Literature

500 mL Carbohydrate Dose 2-3 Hours Before Anesthesia

The largest dose given was 500 mL of the identified CHO drink in 2 of the studies. Yang et al. (2012) used 500 mL 2-3 hours before induction of anesthesia, while Tsutsumi et al. (2016) used 500 mL 2 hours prior. The results of Yang et al. (2012) showed blood glucose and insulin were lower post-operatively in the CHO group compared to the placebo, and HOMA-IR was significantly lower in the CHOD group. Tsutsumi et al. (2016) also reported that their intervention resulted in a lowered surgical stress response, as their CHO group significantly lower serum-free fatty acid levels and total ketone bodies in comparison to the control. Additionally, the preoperative VAS scores for anxiety, hunger, and thirst were higher in the control group than in the CHO group and the PHQ-9 score was significantly lower in the CHO group than in the control. Both studies completing 500 mL of dose 2-3 hours before surgery experienced positive results.

400 mL Carbohydrate Dose 90 minutes Before Anesthesia

400 mL of the carbohydrate drink 90 minutes before induction of anesthesia was completed by Yagmurdur et al. (2011). This study also saw positive results, with the CHO group experiencing less hunger, thirst, malaise, and unfitness perioperatively and less anxiety pre-surgery. There was also improved insulin response in the CHO group and MAP was better stabilized in the CHO group than the control at 10 and 20 minutes after anesthesia.

400 mL Carbohydrate Dose 2 Hours Before Anesthesia

400 mL of the selected carbohydrate drink 2 hours before induction of anesthesia was the most common dose and time. Nine studies implemented this intervention (Hausel et al., 2005; Kaska et al., 2010; Lee et al., 2018; Lidder et al., 2013; Mathur et al., 2010; Qin et al., 2022; Sada et al., 2014; Shi et al., 2020; Yilmaz et al., 2013). 3 studies reported increased well-being with this intervention (Kaska et al., 2010; Sada et al., 2014; Yilmaz et al., 2013) and 2 studies reduced PONV (Hausel et al., 2005; Yilmaz et al., 2013). Although PONV was decreased in Lee et al. (2018), it was not statistically significant, and researchers saw no additional significant differences in outcomes in the study. Reductions in insulin resistance and preserved insulin sensitivity were also seen with this intervention, with 4 studies seeing positive outcomes (Kaska et al., 2010; Lidder et al., 2013; Qin et al., 2022; Shi et al., 2020). Mathur et al. (2010) experienced no major significant differences, although cortisol levels were lowered on POD 1; Kaska et al. (2010) reported statistically significant reductions in the body's inflammatory response and improved cardiac function. Lidder et al. (2013) also saw improved lung function, better handgrip strength post-surgery, and decreased complications compared to their placebo group. However, it should be noted that Lidder et al. (2013) included a postoperative CHO drink once per day until discharge in addition to the preoperative CHO load.

400 mL Carbohydrate Dose 2-3 Hours Before Anesthesia

400 mL 3 hours before induction (Henriksen et al., 2003; Noblett et al., 2006; Vigano et al., 2012; Wang et al., 2010; Wongyingsinn et al., 2019) and 400 mL 2-3 hours before induction (Yildiz et al., 2013; Yuill et al., 2004) were also common interventions. Wongyingsinn et al. (2019) did not see significant differences in walking capacity as studied but did report small, non-statistically significant differences in increased patient satisfaction and shorter median LOS.

Two studies reported increased muscle function, possibly by attenuating the metabolic response to surgery (Henriksen et al., 2003; Yuill et al., 2004). 2 studies noted increased well-being after the preoperative CHO load (Wang et al., 2010; Yildiz et al., 2013) and 2 studies also saw an attenuated stress response through better control of insulin (Vigano et al., 2012; Wang et al., 2010).

400 mL Carbohydrate Dose 12-2 Hours Before Anesthesia

One study completed 400 mL after midnight up to 2 hours before induction of anesthesia (Bisgaard et al., 2004). There were no statistically significant differences with this intervention.

250 mL Carbohydrate Dose 2 Hours Before Anesthesia

250 mL 2 hours before anesthesia was the intervention for one study, Hamamoto et al. (2018). Results showed attenuated loss of lower limb muscle mass and prevention of loss of body weight through this intervention.

200 mL Carbohydrate Dose 2 Hours Before Anesthesia

Another common intervention was 200 mL of their chosen CHO drink 2 hours before induction of anesthesia (Dock-Nascimento et al., 2011; Helminen et al., 2019; Ravanini et al., 2015; Risvanovic et al., 2019; Singh et al., 2015). Results included a range of benefits: decreased cortisol levels and inflammatory cytokine levels with administration of CHO (Dock-Nascimento et al., 2011; Risvanovic et al., 2019), increased well-being (Helminen et al., 2019; Risvanovic et al., 2019; Singh et al., 2015), and decreased insulin resistance (Ravanini et al., 2015).

200 mL Carbohydrate Dose 3 Hours Before Anesthesia

200 mL 3 hours before induction of anesthesia was the intervention for one RCT (Webster et al., 2014). This study did not report any significant differences from the intervention.

Although the time to first bowel movement and more patients in the control group experienced adverse events, it was not considered statistically significant.

Conclusion

The review and synthesis of the literature revealed the most common CHO dose was a 400 mL morning dose 2 hours before induction of anesthesia. 400 mL 2-3 hours or 3 hours before induction of anesthesia was also a common intervention. Positive results showing attenuation of the metabolic stress response were seen over multiple doses and times, demonstrating an advantage to providing any amount of CHO before surgery, even if it is small. A large range of benefits were recorded, including attenuating the stress response, maintaining muscle mass, lowering feelings of discomfort, decreasing PONV, increasing patient satisfaction, and reducing the length of stay. These findings of common doses for abdominal surgery, the range of positive outcomes recorded, and the support unanimously across all articles for CHO loading's safety emphasize how beneficial CHO loading can be for patients undergoing abdominal surgeries. These protocols can be safely adapted to fit a pediatric population to make an impact on recovery post-surgery.

Pediatric patients will experience benefits from the implementation of CHO loading protocols. First, pediatric patients may tend to associate the hunger and thirst of being NPO with pain, increasing their feelings of discomfort before an operation. Additionally, pediatric oncology patients are already at a greater risk for infections and delayed wound healing (American Cancer Society, 2020). Many pediatric cancer patients are considered malnourished, which only further increases infection risk (Joffe & Ladas, 2020). When cancer treatment is delayed due to infections or improper healing, it can have major detriment to the patient. In a systematic review of seven types of cancers and the effects of delayed treatment, the investigators found that even a short delay in cancer treatment of four weeks was associated with an increased risk of mortality (Hanna et al., 2020). We understand that consistent proper nutrition is key in development for children and even more imperative for pediatric cancer patients; acute nutritional status has a profound impact on treatment outcomes as well. Creating the “fed state” for the patient through CHO loading is a safe implementation that may help increase patient satisfaction, lower discomfort, and attenuate the surgical stress response for a range of surgical procedures in pediatrics just as it has for adults.

In terms of application, this scoping review shows it may not be necessary to standardize the CHO dose as it is about getting pediatric patients CHO before surgery. Since CHO loading is a safe practice when using clear CHO drinks (usually containing maltodextrin as the complex CHO), any amount can show advantages in recovery post-surgery.

Next Steps for Implementation

The next step is gaining proper interdisciplinary buy-in and ensuring patients have easy access to the drink itself, as well as an understanding of the protocols. The investigative team had several collaborative communications with the ERAS champions including MD Anderson, Texas Children’s Hospital, and the University of Texas Southwestern, Dallas, TX.

The first discussions were with ERAS champions at MD Anderson, Hematology Oncology Department, a team of researchers developed an implementation program of several ERAS protocols, including CHO loading, minimized use of drains and opioids, and early mobilization for pediatric oncology patients (Wells et al., 2021). Their team recommends 3-5 mL/kg of any CHO drink (including apple juice, Clearfast, Pedialyte, Gatorade, Powerade, etc.) 2 hours prior to surgery. They implemented their program through a “soft launch” in 3 different patients over 4 surgeries. The study reported positive results, with a decreased average length of stay (patients #1 and #3 went home on postoperative day two compared to a usual LOS of 4.3 to 5 days and patient #2 was discharged at the average time) and decreased opioid use (patient #1 did not need opioids and patients #2 and #3 required fewer doses than average) with no increase in surgical complications. The team at MD Anderson plans to continue their ERAS implementation program.

The second communication was with Dr. Nihar Patel (personal communication, March 2023) from Texas Children's Hospital, an advocate for pediatric ERAS program implementation. During a Cook Children's Health Care System Hematology/Oncology Grand Rounds (02/28/2023), Patel emphasized through his own experiences the importance of adherence to protocols chosen by the interdisciplinary healthcare team. He also noted that the fewer protocols there are, the higher the success of implementation. For this reason, we recommend that CHO loading is implemented by the healthcare team as an intervention alone, instead of trying to implement several new ERAS protocols at once. This way, the benefits of CHO loading can be observed and recorded accurately and changes that need to be made will be recognized quickly.

Additionally, the accessibility of the drink should not be a roadblock for pediatric patients and their families. Dr. Stephen Kimatian, the Pediatric Anesthesiologist-in-Chief at Children's Health in Dallas, emphasized this point (S. Kimatian, personal communication, March 2023). For the protocols at Children's Medical Center Dallas, Dr. Kimatian emphasized the CHO drink should be available at grocery stores around their area and should be cheap as well as enjoyable in taste. Their program implements CHO loading 3 hours prior to the operation, and the pre-op nurses are trained to explain benefits and protocols for clear fluids so that even outpatient surgery patients receive CHO loading in some form. However, for their inpatient surgeries, their algorithm is 10 mL/kg to initiate a strong enough fed response for the patient. Dr. Kimatian states that his patients are encouraged to drink a range of clear fluids including Gatorade, Pedialyte, or fruit juices as long as they are not colored red. By giving options to the children, the drinks are more likely to be effectively ingested and therefore more effective in enhancing recovery post-surgery.

Through the scoping review of the literature on CHO loading specifically and conversations with a range of members in the interdisciplinary healthcare team, there is sufficient literature to support the use of CHO loading as a safe, feasible, effective implementation to improve recovery for pediatric oncology patients.

Appendix A

Table 1

Evidence Supporting Carbohydrate Loading and Improved Outcomes

Citation/ Database/ Country/ JH Level	**Design/Objectives**	**Sample**	**Intervention/CHO Loading/Type/Amount/Dose**	**Outcomes Measured**	**Results**	**Conclusion/Implications**
(Bisgaard et al., 2004) Medline Complete Denmark **Level 1**	Randomized clinical trial measuring the impact of CHO loading on general well-being after laparoscopic cholecystectomy.	-86 patients (18-75 yrs) undergoing laparoscopic cholecystectomy.	**CHO group (n=43)** -800 mL of a carbohydrate-rich drink (12.5% carbohydrate, 50 kcal per 100 mL, 290 mOsm/kg, pH 5.0, Nutricia PreOp) the evening before operation or between 2000 and 2400. -After midnight, 400 mL of same beverage - over 10 minutes morning of operation UP TO 2 hours before anesthesia. **Placebo group** (n=43) received flavored sweetened water in same manner as CHO group.	-5 days prior to operation to 5 days post operation. -Well-being, fatigue, appetite and pain, computerized measurements of physical activity and sleep (actigraphy), subjective sleep quality recorded. -Assessed nausea and vomiting twice within 24 hours post-surgery.	No significant differences reported in any values. Pain scores remained increased significantly in the CHO group POD4 (p = .001).	No significant improvement is seen from administration of carbohydrate beverage pre-laparoscopic cholecystectomy. Authors hypothesize this finding may be connected to the idea that a laparoscopic cholecystectomy is a minimally invasive procedure and does not affect insulin sensitivity greatly. **NO SIGNIFICANT DIFFERENCE**
(Dock-Nascimento et al., 2011) Medline Complete Brazil Level 1	Randomized controlled trial evaluating the impact of maltodextrin and glutathione administration on insulin resistance, the inflammatory response, and antioxidant defenses after laparoscopic cholecystectomy.	48 female patients (18-65 yrs) undergoing laparoscopic cholecystectomy.	**CHO group (n=12)** -400 mL water with 50g of maltodextrin (240 mOsm) 8 hours prior and -200 mL at 2 hours prior to anesthesia. **Fasting group** (n=12) underwent standard 8 hour fast prior to surgery.	-Blood samples collected - anesthesia and 10 hours post-surgery before the first liquid meal. -Insulin resistance - HOMA-IR, serum GSH peroxidase levels, CRP, prealbumin, albumin, and IL-6.	-Postoperative HOMA-IR higher in control patients (4.3[1.3]) compared with the placebo (1.6[0.3] p = .03), CHO (2.3[0.4] p = .02), and GLN (1.5[0.1] p = .01) groups. -CRP/Albumin levels were greater in control patients (0.99[0.13]) compared to CHO (0.50[0.14] p = .02) and GLN group (0.50[0.13] p = .01).	Standard 8-hour fast associated with increased insulin resistance, enhanced acute-phase response, and less pronounced decrease in serum cortisol. All three beverages decreased insulin resistance and serum cortisol levels compared to fasting. **CHO lessened the CRP/albumin ratio post-operatively.**

Citation/ Database/ Country/ JH Level	**Design/Objectives**	**Sample**	**Intervention/CHO Loading/Type/Amount/Dose**	**Outcomes Measured**	**Results**	**Conclusion/Implications**
			Placebo group (n=12) ingested 400 mL of water at 8 hours and 200 mL of water at 2 hours prior to anesthesia. **GLN group (n=12)** received 400 mL water with 50g of maltodextrin and 40g glutamine (639.2 mOsm) at 8 hours and 200 mL at 2 hours prior to anesthesia.		-IL-6 showed no significant differences regarding the CHO group. -Nitrogen balance was similar in the CHO (-6.0[0.4] *p* = .04) and GLN groups.	Study supported GLN with CHO and CHO loading.
(Hamamoto et al., 2018) Medline Complete Japan **Level 1**	Single-center, prospective, single-center RCT measuring the impact of CHO loading on intraoperative core temperature during surgery	64 patients (20-85 yrs) undergoing elective laparoscopic colon cancer surgery	**CHO group (n=31)** - 500 mL Arginaid Water night prior to surgery and -250 mL 2 hr. prior to induction of anesthesia. -If afternoon operation, CHO group received an additional 250 mL 2 hr. prior to anesthesia. **Control group (n=33)** -water only until 2 hours prior to anesthesia.	-Axillary temperature prior to surgery. -Intraoperative esophageal temperature 150 mins after start of surgery. -Compared axillary temperature and esophageal temperature q30 mins.	-Core temperature - CHO group 90, 120, 150 mins after surgery was significantly lower than control (90 min: 36.26 vs 36.05°C, *p* = .0233; 120 min: 36.30 vs 36.06°C, *p* = .0283; 150 min: 36.33 vs 36.01°C; *p* = .0186). -Significant difference in body weight loss and loss of lower limb muscle mass (-1.6 vs -0.9 kg, *p* = .0304; - 0.7 vs - 0.3 kg, *p* = .0110). -LOS, rate of complications, first day of flatus, defecation, solid food not significantly different. -Leukocyte and lymphocyte count not significantly different.	CHO had no effect on raising intraoperative temperature and lowered intraoperative temperature. **CHO prevented the loss of body weight and lower limb muscle mass, which can have a beneficial effect on early ambulation post-surgery.** No significant effect on short-term outcomes. **No negative impact on perioperative outcome.**
(Hausel et al., 2005) Medline Complete Sweden **Level 1**	Randomized clinical trial measuring the effects of CHO on PONV after laparoscopic cholecystectomy.	172 adult patients (mean age 48 years) from 3 hospitals studied. 127 women, 45 men. Fasted group (n=58), placebo group (n=59), and CHO group (n=55).	**CHO (n=55)** - 800 mL of CHO drink (12.5% carbohydrates, 50kcal/100mL, 290 mOsm/kg, pH 5.0, Nutricia PreOp) the evening before surgery	- PONV and patients rated patient PONV through the VAS 1 week prior to surgery and the day after surgery. -VAS scores for pain also obtained.	-Incidence of PONV decreased significantly over time in CHO (0-4hr post-surgery PONV episodes n = 14, vomiting n = 3; 4-12hr PONV episodes n = 5, vomiting n = 0; 12-24hr PONV episodes n = 1, vomiting n = 0; *p* < .001) and placebo group (0-4hr post-surgery PONV episodes n = 15, vomiting n = 1,	**CHO administration lowered instances and feelings of nausea and vomiting.** **Data suggests CHO might reduce nausea and vomiting after laparoscopic cholecystectomy.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
			-400 mL of the same drink at least 2 hours before anesthesia. Fasting from midnight group allowed nothing by mouth after midnight prior to surgery. **Placebo group (n=59)** ingested 800 mL of flavored water the evening before surgery and 400 mL of the same drink at least two hours prior to anesthesia.		4-12hr PONV episodes n = 8, vomiting n = 3, 12-24hr PONV episodes n = 4, vomiting n = 1; *p* = .006). -0 patients receiving CHO vomited in the first 4 hours post-op in comparison to several patients in both the placebo and fasted groups. -Nausea VAS scores higher in fasted and placebo groups post-op, but no significant difference in nausea in CHO group (*p* = .082).	
(Helminen et al., 2019) Medline Complete Finland **Level 1**	Randomized controlled trial measuring whether pre-operative CHO loading enhances recovery post day-case cholecystectomy.	113 patients aged 18-70 undergoing day-case cholecystectomy. CHO group (n=53) and fasting group (n=53) between 2013 and 2016.	**CHO group (n=53):** - 200 mL of carbohydrate-rich drink (Providextra; 300 kcal, 67-g carbohydrate, 8g protein) at home prior to leaving for hospital, by 0600 for 0800 surgery, or by 0800 latest for later surgeries. -**Fasting group** (n=53) nothing by mouth.	-VAS upon arrival-repeated immediately before operation, 2 hr. and 4 hr. post-surgery, and at discharge evaluating hunger, thirst, mouth dryness, tiredness, nausea, pain. -BG levels measured upon arrival to hospital and 2 hr. post-surgery.	-Highest VAS scores seen in thirst before induction of anesthesia in the fasting group, then for thirst, mouth dryness, and tiredness 2 hours post-surgery in both groups. -CHO decreased thirst before surgery (22 vs 40). -BG levels did not significantly differ between the two groups. -No apparent or suspected pulmonary aspiration or differences in postoperative outcomes or need for analgesia and antiemetic treatment.	CHO loading did not improve or decrease the well-being of patients after day-case cholecystectomy. Outcomes did not differ significantly between the two groups. CHO decreased thirst pre-operatively compared to fasting group.
(Henriksen et al., 2003) PubMed Denmark	Randomized controlled trial measuring effect of oral carbohydrate drink or oral carbohydrate drink with peptides on postoperative voluntary muscle	48 adult patients included undergoing elective bowel resection.	**CHO group (n=16)** - 400 mL of a carbohydrate drink (12.5g/100 mL maltodextrin) the night before surgery just before sleeping and -400 mL the morning of surgery, no later than 3 hours	-Blood samples obtained at admission, 1 hour before surgery, 4 hours after starting surgery, and in the morning POD 1 and POD 3. -Voluntary grip and quadricep strength (measured by dynamometer), body	-Serum insulin concentrations lower in the fasting group compared to the two intervention groups before the operation ((4hr CHO group 31, CHO-P 46, control 29; *p* = .002) -Intervention groups had significantly better muscle	There is clinical significance to preoperative CHO loading's impact on muscle function in major abdominal surgery.

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
Level 1	strength, nutritional intake and ambulation, postoperative fatigue, anxiety and discomfort, and the endocrine response for elective bowel resections.		before the induction of anesthesia and were allowed water prior to 3 hours before anesthesia. **CHO-P group (n=16)** received 400 mL of a carbohydrate drink (12.5g/100 mL maltodextrin) with peptides (3.5g/100mL hydrolyzed soy protein) the night before surgery just before sleeping and were allowed water prior to 3 hours before induction of anesthesia. **Fasting group (n=16)** fasted from midnight, only water prior to 3 hours before anesthesia.	composition, pulmonary function, -VAS-score for wellbeing, muscle biopsies, insulin, glucagon, IGF-1, free fatty acids measured before and after operation.	strength compared with control group (10-11% decrease in strength in CHO and CHO-P group vs 16% in the control group, $p < .05$) after 1 month. -VAS scores did not significantly differ among the three groups.	
(Kaska et al., 2010) From Dr. Bashore Czech Republic **Level 1**	Bicentric, prospective, blinded, randomized controlled trial measuring impact of preoperative oral carbohydrates vs IV glucose infusion for patients undergoing elective colorectal surgery.	221 adult elective colorectal surgery patients (35-75 years old) included. 122 men, 99 women.	**Oral CHO group (n=74)** - 400 mL of maltodextrin and electrolytes (PreOp Nutricia; 12.6% maltodextrin, 2.1g fructose, 50g Na, 122g K, 6mg Cl, 6mg Ca, 1mg P, 1mg Mg, 240 mOsmol/l, energy 215 kJ) twice; once the evening before surgery -400 mL the second time up to 2 hours before surgery. **Control group (n=75)** involved patients fasting from midnight. **IV glucose group (n=72)** received IV administration of 500 mL of 10% glucose with 10 mL of 7.45% KCl and 20mL of MgSO4 twice; once in the evening before surgery and the second time in the morning	-Carbohydrate metabolism, hydration and minerals, damage to muscle tissue, inflammatory response to operation measured through blood samples. -Serum concentrations determined using MODULAR system. -Serum concentration of insulin using radioimmunoassay. -Insulin resistance measured using quantitative insulin sensitivity check index. -Cardiac function assessed with echocardiographic examination.	LOS did not differ significantly between groups. Rate of complications did not differ significantly. Psychosomatic conditions best in oral CHO group with statistical significance. ($p < .001$ postoperatively vs $p < .029$ postoperatively). Insulin serum concentration appeared physiologically in oral CHO group, showing lowest insulin resistance in this group. Cardiac function improved overall in oral CHO group compared to other two groups with increased ejection fraction (oral CHO group 67.1, IV glucose group 65.7, fasting group 65; $p < .05$).	**Oral CHO increases wellbeing of patients undergoing elective colorectal surgery and decreases discomfort.** **Oral CHO preserved insulin sensitivity.** **C-reactive protein lowest in oral CHO group, indicating lowest inflammatory response.** **Preservation of cardiac performance when patients receive oral CHO prior to elective colorectal surgery.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
			between 6 hours and 2 hours before surgery.	-Psychosomatic status measured by Beck questionnaire. -Muscle power measured using digital tension meter on POD 1,3, and 7.	C-reactive protein lowest in IV glucose and CHO group (Day 0 fasting group 6, IV glucose group 2.00, oral CHO group 4.5. Day 1 fasting group 89.9, IV glucose group 83.2, oral CHO group 86.7; Day 3 fasting group 125, IV glucose group 108, oral CHO group 101; Day 7 fasting group 24, IV glucose group 29, oral CHO group 21.5). Gastric residual volumes and pH best in oral CHO group, no risk added with oral fluids.	
(Lee et al., 2018) Medline Korea **Level 1**	Randomized, double-blind, placebo-controlled trial measuring effect of CHO loading on patient satisfaction and overall recovery.	153 adults undergoing laparoscopic cholecystectomy between September 2015 and December 2016. No-NPO (n=46), Placebo (n=44), MN-NPO (n=51).	**CHO group (n=46; NO NPO**) - 400 mL of clear CHO drink (No-NPO; 12.8% CHO, 50 kcal/100 mL, 290 mOsm/kg) the evening before surgery from 2000-2200 and -400 mL 2 hours prior to induction of anesthesia. MN-NPO (n=51) not allowed to drink any solution or fluid after midnight before surgery. Placebo group (n=44) received same amount of fluid at same times as No-NPO group but received flavored water instead.	-Utilized 40-item questionnaire post-surgery. -Recorded heart rate and MAP at nine time points: before and after induction of anesthesia, before positional changes during surgery, 5 times after positional changes performed every 2 mins.	MN-NPO group had elevated heart rate compared to No-NPO and placebo groups. Reduction in antiemetic consumption, but not statistically significant (1] [2%] in the CHO group versus 4 [8%]) in the other two groups, *p* = .532) No significant difference in MAP between groups. No complications associated with preoperative hydration.	Reduced PONV in No-NPO group but not statistically significant. Vascular capacity of patient declines with prolonged fasting times, affecting hemodynamic stability but not different for No-NPO vs placebo. No additional complications with No-NPO or placebo. No-NPO did not improve quality of recovery, more studies are needed to determine patient satisfaction. **NO SIGNIFICANT DIFFERENCE**
(Lidder et al., 2013) Medline Complete United Kingdom Level 1	Prospective four-arm double-blind controlled trial evaluating effects of carbohydrate drinks on insulin resistance as well as handgrip	120 adult patients undergoing planned curative resection with primary anastomosis of histologically confirmed colorectal	**Full CHO group (n=27)** Group D (n=27) received 400 mL of preoperative carbohydrate drink (Nutricia PreOp; 50kcal/100mL, 290 mOsm/kg, pH 5.0) 2 hours prior	-On POD 1, 2, 3, a fasting peripheral venous blood sample was drawn at 0800 for C-reactive protein (CRP) and insulin.	Handgrip strength improved faster in groups C and D compared to group A (*p* < .001 and p = .002). Peak expiratory flow rate improved in groups B and D	Patients who received preoperative CHO loading and postoperative supplements after elective colorectal cancer resection **improves insulin resistance, pulmonary function,**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
	strength, pulmonary function, intestinal permeability, and postoperative complications.	cancer. Group A, B, C, D.	to surgery and 600 mL postoperative polymeric nutritional supplement drink (Fortifresh; 150kcal/100mL, 965 mOsm/kg, pH 4.2) per day until discharge. **Partial CHO group (n=32)** Group B (n=32) received 400 mL preoperative carbohydrate drink (Nutricia PreOp; 50kcal/100mL, 290 mOsm/kg, pH 5.0) 2 hours prior to surgery and 600 mL postoperative placebo drink (acesulfame-K and citrate, 0kcal/100mL, 107 mOsm/kg, pH 4.2) a day until discharge. **Partial CHO group (n=31)** Group C (n=31) received 400 mL of preoperative placebo drink (acesulfame-K, 0.64g/100mL citrate, 0kcal/100mL, 107 mOsm/kg, pH 5.0) 2 hours prior to surgery and 600 mL postoperative polymeric nutritional supplement drink (Fortifresh; 150kcal/100mL, 965 mOsm/kg, pH 4.2) per day until discharge. Group A (n=30) received 400 mL of preoperative placebo drink (acesulfame-K, 0.64g/100mL citrate, 0kcal/100mL, 107 mOsm/kg, pH 5.0) 2 hours prior to surgery and 600 mL postoperative placebo drink (acesulfame-K and citrate, 0kcal/100mL, 107	-HOMA-IR and insulin tolerance tests (ITT) assessed for insulin resistance. -VAS-scores monitored for wellbeing. -Complications, handgrip strength, bowel function measured. Small bowel permeability assessed. -Peak expiratory flow rate assessed.	compared with group A (p = .002 and p = .035). ITTs decreased in group B (p = .044) and group D (p = .044) compared with group A, indicating preoperative carbohydrates help with insulin sensitivity. HOMA-IR improved most group D (p = .011). Patients in group D experienced fewer clinical complications than those in group A (total number of complications by postoperative day (POD) #5; partial CHO groups n = 17, and n = 20, and n = 20 in the placebo group; p = .003). No differences in LOS between the 4 groups.	**handgrip testing** compared with patients receiving placebo drinks. **Data shows CHO loading preoperatively is beneficial to insulin sensitivity.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
			mOsm/kg, pH 4.2) a day until discharge.			
(Mathur et al., 2010) Medline Complete New Zealand Level 1	Randomized controlled trial evaluating the effect of preoperative CHO loading on postoperative length of stay and fatigue.	142 adult patients between the ages of 18-80 undergoing elective colorectal surgery or liver resection. CHO group (n=69) and placebo group (n=73).	**CHO group (n=69)** - consisted of evening before surgery between 1900 and 2400 consumed 800 mL of Nutricia PreOp (12.5% CHO, 50 kcal/100 mL, 290 mOsm/kg, pH 5.0) and 400 mL 2 hours before induction of anesthesia over 20 minutes. Water allowed. Placebo Group (n=73) consisted of evening before surgery between 1900 and 2400 consumed 800 mL of flavored water with artificial sweetener (acesulfame-K, 0.64 g/100 mL citrate, 0 kcal/100 mL, 107 mOsm/kg, pH 5.0) and 400 mL 2 hours before induction of anesthesia over 20 minutes. Water allowed.	-Postoperative fatigue was measured using a VAS scale. -Postoperative length of stay determined from date of discharge and a "fit-for-discharge" date. -Glucose measured by hexokinase method and insulin measured by microparticle immunoassay. Insulin resistance measured by HOMA-IR. -Electrochemiluminescence immunoassay to measure serum cortisol and an immunoturbidimetric method for high-sensitivity CRP assay. -Grip strength measured using a dynamometer. -Total body nitrogen measured.	VAS score for fatigue and discomfort did not significantly differ between groups. Median length of stay was 7 days in CHO group and 8 days in placebo group (p = .344). Length of stay "fit-for-discharge" were 6 (2-35) days in the CHO group and 7 (2-92) days in the placebo group (p = .523). No significant differences in glucose, insulin, and CRP seen between the groups. Cortisol concentration significantly lower in CHO group on day 1 after surgery (POD0 416(27) vs 445(24); POD1 219(34) vs 473(44); POD3 495(40) vs 511(26); POD5 540(22) vs 524(33); POD7 575(36) vs 591(56); POD28 407(36) vs 417(25); $p <$ .001). HOMA-IR did not differ significantly but was higher than the baseline in the placebo group on days 1,5, and 7 and did not differ from the baseline in the CHO group. Grip strength and total body protein did not significantly differ.	Study shows the administration is safe. No significant beneficial effects found, and a more homogenous group is needed to determine benefits. **NO SIGNIFICANT DIFFERENCE**
(Noblett et al., 2005)	Randomized controlled trial evaluating effect of	36 adult patients undergoing elective colonic resection	**Group 2 CHO group (n=10)**	-Muscle strength measured using dynamometer.	The median time to fitness to discharge was 10 days in the fasting group, the water group	**Preoperative administration of carbohydrates are safe to**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
Medline Complete United Kingdom Level 1	pre-operative carbohydrate administration on grip strength, gastrointestinal function, and hospital stay after elective colorectal surgery.	randomized into 3 groups: Group 1 (n=11), Group 2 (n=10), Group 3 (n=12).	-received 100g Precarb (96.0 g CHO /100g, 380 kcal/100g, 285 mOsm/100g) dissolved in 800 mL of water the night before surgery and 50g of Vitajoule dissolved in 400 mL of water 3 hours prior to induction of anesthesia. Group 3, or the fasting group, (n=12) was fasted from midnight prior to the surgery. Group 1, or the placebo group, (n=11) received 800 mL of water the night before surgery and 400 mL of water 3 hours prior to induction of anesthesia.	-Time until fitness for patient discharge recorded. -Time of passage to first flatus and first bowel movement were recorded.	was 13 days, and the CHO group 7.5 days. A statistically significant difference was seen between CHO and water group (*p* = .019). No statistically significant difference found in passage of first flatus but a trend toward earlier return was seen in CHO group. Earlier bowel movement seen in CHO group compared with those who fasted (*p* = .2) and those who drank water only (*p* = .06). No significant difference in grip strength between the groups.	**administer and lowered length of hospital stay significantly.** There is also a trend toward earlier return of gastrointestinal function in the carbohydrate group.
(Qin et al., 2022) PubMed China Level 1	Prospective, multicenter, parallel-controlled, double-blind clinical study evaluating efficacy of oral administration of maltodextrin and fructose before major abdominal surgery.	223 adult patients aged 45-70 undergoing elective gastrectomy, colorectal resection, or duodeno-pancreatectomy. Intervention group (n=112) and control group (n=111).	All patients fasted for 6 hours before surgery. **CHO/ Intervention group (n=112)** -received 800 mL 10 hours before the operation and 400 mL 2 hours before the operation of a 12.5% maltodextrin/fructose mixture solution (Suquian). Control group (n=111) received 800 mL of water 10 hours before the operation and 400 mL 2 hours before the operation.	-Primary endpoint was homeostasis model assessment insulin resistance index (HOMA-IRI) calculated and measured before surgery and on days 1 and 3 post-surgery. -Secondary endpoints included fasting blood glucose, fasting insulin, insulin secretion index, insulin sensitivity index, subjective well-being using a VAS-scale, blood glucose, and clinical outcomes.	Significant difference in HOMA-IRI between intervention group and control group (POD1 11.38 (16.11) vs 20.21 (42.27); POD3 7.19 (7.3) vs 14.91 (59.48); *p* = .02). The control group showed significantly higher HOMA-IRI. The CHO group experienced lower levels of anxiety (1.76 (1.71) vs 2.43 (2.44)), lower nausea (1.42 (1.67) vs 2.19 (2.81)), and a lowered appetite (2.04 (2.03) vs 2.15 (1.89)) preoperatively. LOS and time to passage of first flatus were also lower in the CHO group, but not statistically significant (11.29 vs 11.67; *p* =	**Oral administration of carbohydrates reduced insulin resistance.** It is safe to administer.

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
					.6762; 3.29 vs 3.25; *p* = .7902; respectively).	
(Risvanovic et al., 2019) Medline Complete Bosnia & Herzegovnia Level 1	Prospective randomized controlled trial evaluating the effect of preoperative oral CHO loading on the postoperative metabolic and inflammatory responses, perioperative discomfort, and surgical clinical outcomes in open colorectal surgery.	50 adult patients between the ages of 18-70 scheduled for open radical resection of colorectal cancer. CHO group (n=25) and FAST group (n=25).	**CHO group/intervention (n=25)** -received 400 mL of a clear carbohydrate drink (12.5g/100mL maltodextrin, 50kcal/100mL, pH 5.0) at 22 hours the evening prior to surgery and 200 mL 2 hours before induction of anesthesia. Control group, or FAST group (n=25), fasted 8 hours prior to surgery.	-Clinical biochemical parameters were assessed from peripheral venous blood samples, including glucose, insulin, CRP, albumin, and IL-6. -Insulin resistance calculated using HOMA-IR. -Subjective patient well-being and pain scores assessed using a VAS-scale. -Surgical outcomes evaluated by postoperative return of gastrointestinal function, time to independent ambulation, and postoperative discharge day. Time of postoperative flatus and defecation recorded.	Insulin and JOMA-IR levels higher in FAST group than CHO group during all study periods. HOMA-ISI levels lower in FAST group than CHO group. Total increase of HOMA-IR was 30% lower in CHO group. Total reduction of HOMA-ISI was 54% in FAST group and 39% in the CHO group. Significantly decreased CRP and Il-6 levels in CHO group (CRP 6hr post-surgery 18.3 vs 52.7, *p* = .001; 06hr POD1 62.9 vs 52.7, *p* = .001; 06hr POD2 83.8 vs 125.3, *p* = .001; and IL-6 6hr post-surgery 123.7 vs 347.4, *p* = .001; 06hr POD1 48.4 vs 143.2, *p* = .001; 06hr POD2 19.9 vs 48.5; *p* = .001; respectively). Serum albumin decreased significantly between each studied time point in FAST group (*p* < .05) but did not decrease significantly in the CHO group. Significantly higher levels of IL-6 displayed in FAST group. VAS scores were significantly higher in FAST group. Incidence of nausea was significantly higher in FAST group (*p* < .02 and *p* < .04). CHO group experienced significantly faster return of GI	**Oral administration of carbohydrates provided better postoperative glycemic control, enhanced insulin sensitivity, and attenuated the inflammatory response.** CHO loading is considered safe and effective for open colorectal surgery. CHO loading did not significantly diminish postoperative pain. **CHO loading allows for faster return of GI function, improves patient well-being, and earlier ambulation and discharge.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
					function. Independent ambulation and postoperative discharge day occurred earlier in CHO group.	
(Ravanini et al., 2015) Medline Complete Brazil Level 1	Randomized prospective controlled trial evaluating the effect of a carbohydrate and protein rich solution on laparoscopic cholecystectomy.	38 adult females over 18 years old with cholelithiasis included in study. Group A (n=17) and Group B (n=21).	**Group B/ CHO (n=21)** -received 200 mL of carbohydrate and protein solution (Fresubin Jucy Drink; 150kcal/100mL, 4g protein/100mL, 33.5g CH/100mL, 0g lipids/100mL) 2 hours prior to the procedure. **Group A (n=17**) received conventional fasting conditions beginning at 2200 the night prior to surgery.	-Nausea, vomiting, pain assessed at 4hr, 8hr, 24hr post-surgery. VAS-Pain -Serum glucose, insulin, IL-1, tumor necrosis factor-alpha levels collected and measured. -Insulin resistance via HOMA-IR	-Group A higher postoperative levels of serum insulin and insulin resistance compared to Group B (-13.2% vs 10.4%; *p* = .01; 7.5% vs 38.7%; *p* = .001, respectively). -Insulin variance was also significantly different between the two groups. -IL-1 and TNF-alpha did not present differences. -No significant difference in nausea, vomiting, and pain between the two groups.	CHO loading is safe, with no events of regurgitation or bronchoaspiration. **CHO loading group presented with less insulin resistance** and may have experienced a reduced organic response to trauma.
(Sada et al., 2014) PubMed Kosovo Level 1	Randomized, double-blind, prospective study evaluating the effect of carbohydrate-rich drinks on well-being and clinical status of patients undergoing open colorectal operations and open cholecystectomy.	142 adult patients older than 18 years undergoing operations for the colon and rectum for benign and malignant diseases or undergoing open abdominal cholecystectomy for chronic cholecystitis included. Patients were organized by surgery. For cholecystectomy: study group (n=22), placebo group (n=23), control group (n=26). For colorectal surgery: study group (n=22), placebo group (n=23), control group (n=26).	**Study groups/ CHO (n=22; n=22)** -received 800 mL of carbohydrate beverage (Nutricia PreOp; 12.5% carbohydrates, 50 kcal/100 mL, 285 mOsml/kg) at 2200 the evening prior to surgery -- additional 400 mL 2 hours before anesthesia. **Placebo groups (n=23; n=23)** received 800 mL of a non-caloric colorless beverage with the same taste at 2200 the night prior to surgery, and an additional 400mL 2 hours before anesthesia. **Control groups (n=26; n=26)** received traditional preoperative	-Patient well-being -VAS before 24hrs post-surgery and between 36-48hrs post-surgery. -Clinical evaluation by the Simplified Acute Physiology Score (SAPS-II) performed within 24 hours post-surgery. -LOS for each patient. -Regaining daily activities	- Thirst was significantly lower in the first 24 hours post-surgery in open colorectal surgery patients (study group median 3, placebo 2, control 4; *p* = .027). - Statistically significant difference compared to the control group in degree of hunger in open cholecystectomy patients (study group median 3, placebo 2, control 4), thirst (study group median 3, placebo 2, control 4), mouth dryness (study group median 5, placebo 4, control 6), nausea (study group median 1, placebo 3, control 2.5), and weakness (study group median 4, placebo 3, control 3) in the first 24 hours after surgery (*p* < .05).	**CHO loading improved thirst in colorectal patients and improved thirst, hunger, mouth dryness, nausea, and weakness in cholecystectomy patients**. Less evident effect in colorectal patients.

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
			fasting beginning at midnight the night prior to surgery.		-No statistically significant differences in LOS between the groups or in regaining daily activities.	
(Shi et al., 2020) Medline Complete China Level 1	Randomized, controlled trial evaluating effects of preoperative oral carbohydrates on insulin resistance for colorectal cancer resection surgery patients.	63 adult patients (20-75 yrs) undergoing elective open colorectal cancer resection. POC group (n=21), fasting group (n=21), placebo group (n=21).	**POC group/ CHO (n=21)** -received 400 mL Nutricia PreOp solution (12.5% carbohydrate, 0.5kcal/mL, 10g polysaccharides, 2.1g sugar, <0.025g lactose/100mL, 240 mOsm/kg, pH 4.9) 2 hours before anesthesia. **Fasting group (n=21)** fasted overnight prior to surgery. **Placebo group (n=21)** received 400 mL of a noncarbonated, lemon-flavored water (pH 4.9) 2 hours before anesthesia.	-Blood samples taken 3 hours before operation and at the end of the operation to measure blood glucose and insulin levels. -Muscle samples - rectus abdominis muscle just before the opening of the peritoneum and at the end of surgery. -Insulin resistance calculated using HOMA-IR. -Western Blot analysis performed.	At the end of the operation, blood glucose, blood insulin, and HOMA-IR were significantly lower in the POC group than fasting and placebo groups ($p < .05$). ISI significantly higher in POC group than fasting and placebo groups ($p < .05$). Post-surgery, phosphorylation of mTOR Ser244, S6K1, and IRS-1 were significantly lower in POC group than fasting and placebo groups. The level of phosphorylated AMPK was significantly higher in the POC group than the other groups.	**Preoperative carbohydrates activated AMPK and suppressed the mTOR, S6K1, and IRS-1 pathways, attenuating insulin resistance after colorectal resection.**
(Singh et al., 2015) CINAHL Complete India Level 1	Randomized, controlled prospective study evaluating the effects of preoperative carbohydrate-rich drinks on postoperative nausea, vomiting, and pain after day care laparoscopic cholecystectomy.	120 adult patients (age 18 and up) undergoing elective laparoscopic cholecystectomy. Group A (n=40), Group B (n=40), Group C (n=40).	**Group A/CHO (n=40)** -Evening before surgery from 2000-2200, patients received 400 mL of a clear carbohydrate-rich drink (12.5% carbohydrates, 50kcal/100mL, 290 mOsm/kg, pH 5.0) and another 200 mL at 0600. **Group B (n=40)** received 400 mL of flavored water (pH 5.0) and another 200 mL at 0600. **Group C (n=40)** fasted starting at midnight.	-Nausea and vomiting. -VAS scores obtained to measure pain.	-Nausea in group A 52.5% in 0-4hrs, 55% in 4-12hrs and 25% in 12-24hrs after surgery. Nausea in group B 87.5% in 0-4 h, 67.5% in 4-12hrs and 42.5% in 12-24 h after surgery. Nausea in C group 80% in 0-4hrs, 75% in 4-12hrs and 53.8% in 12-24hrs after surgery. -Mean nausea score 0-4 h in group A was significantly lower as compared to group B and group C ($p = .001$). Difference in mean score of nausea in 4-12 and 12-24hrs in group A as compared to group B and group C was not significant ($p = .066$), ($p = .257$).	**Preoperative CHO loading lowers incidence of postoperative nausea and vomiting. It also reduces pain scores and is considered safe.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
					-Mean vomiting score 0-4 and 4-12hr in group A was significantly less than that of group B and group C group A 52.5 % in 0–4 h, 55 % in 4–12 h, 25 % in 12–24 h after surgery; group B 87.5 % in 0–4 h, 67.5 % in 4–12 h and 42.5 % in 12–24 h after surgery; group C 80 % in 0–4 h, 75 % in 4–12 h and 53.8 % in 12–24 h after surgery; p = .0006). -Mean score of nausea in 0-4 h in the CHO group was significantly lower as compared to the placebo and fasting groups (group A mean number of nausea episodes 0.65, group B 1.30, group C 1.23; p = .001). -Mean VAS pain score significantly less in group A at 0-4hr and 4-12hr (group A 5.75, group B 7.13, group C 6.95, p = .001) and 4-12hrs (group A 3.53, group B 4.08, group C 4.65, p = .005).	
(Tsutsumi et al., 2016) Medline Complete Japan Level 1	Randomized prospective clinical trial evaluating the effects of oral carbohydrate with amino acid solution on the metabolic status of patients in the preoperative period of minor surgery.	24 adult patients (ages 21-63) undergoing minor surgery were included. ONS group (n=12) and control group (n=12).	**ONS group/ CHO (n=12)** -received 500 mL of Arginaid Water (80kcal/100mL, 2.0g arginine/100mL, 18g CHO/100mL, 140mg phosphate/100mL, 0.8mg copper/100mL, 560-580mOsm/L) 2 hours prior to surgery. **Control group (n=12)** fasted after 2100 the night prior to surgery and was allowed water during fasting period.	-Respiratory quotient and energy expenditure pre and post anesthesia (blood). -VAS-scale and Patient Health Questionnaire (PHQ-9) for well-being.	-ONS group showed significantly lower serum free fatty acid levels (ONS group: 479 (408, 610) µEq/L, p = .0002); control group: 828 (729, 1004) µEq/L) and total ketone bodies (ONS group: 40 [27, 64] µmol/L, p = .037; control group: 119 (68, 440) µmol/L) -No differences in inflammatory markers between the groups. -Preoperative VAS scores- anxiety, hunger, and thirst were higher in the control group than	**Preoperative oral carbohydrate intake decreases levels of FFA and ketone bodies, slowing lipid catabolism before surgery.** Preoperative oral carbohydrate intake also increases patient well-being prior to surgery.

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
					in the ONS group, with no differences in any other measure of subjective well-being between groups. -PHQ-9 score was significantly lower in the ONS group than in the control group.	
(Vigano et al., 2012) Medline Complete Italy Level 1	Controlled, prospective cohort study evaluating effects of preoperative oral carbohydrates on postoperative metabolic stress response in patients undergoing elective abdominal surgery.	76 adult patients undergoing elective abdominal surgery included. OCH group (n=38) and control group (n=38).	**OCH group/ CHO (n=38)** -received 800 mL of a carbohydrate-rich beverage (Nutricia PreOp; 50kcal/100mL, 12.5g carbohydrates/100mL, 285 mOsm/L) between 1800 and 2400 the day before surgery and an additional 400 mL 3hrs **before induction of anesthesia.** **Control group (n=38)** received fasting from midnight the night prior to the surgery and was allowed water during the fasting period.	-Glucose, insulin, insulin resistance assessed - HOMA-IR, -Cortisol, IL-^ assessed at baseline, POD 1, POD 2, POD 3. -Complications & tolerance of the supplemental drink. -LOS	-Preoperative OCH - lower increases in HOMA-IR, levels of glucose, and levels of IL-6, on both POD 1 and POD 2 (POD1 128 vs 186, $p <$ .001; POD2 121 vs 144, $p =$ .001 and POD1 20 vs 199, p < .001; POD2 15 vs 149, p < .001; respectively) and of cortisol on POD 1 (4.8 vs 9.0, $p = .005$; 128 vs 186, $p < .001$; 23.4 vs 28.6, p = .044; respectively). - "Major surgery group" glucose & IL-6 levels were significantly lower than in OCH group also at POD 3. -Preoperative OCH appeared associated with lower rates of infectious complications in patients undergoing major abdominal surgery (0 vs 5, $p =$ .054). -No significant differences in LOS were observed between treatment group.	**Preoperative oral carbohydrate-rich drink attenuated postoperative metabolic stress response.** Considered safe.
(Wang et al., 2010) Medline Complete China	Randomized controlled trial evaluating effects of preoperative oral carbohydrates versus placebo on insulin	48 adult patients (25-75 yrs) undergoing colorectal resection. OCH group (n=16) and placebo group (n=16) double-blinded, fasting	**OCH group/ CHO (n=16)** -received 400 mL of Nutricia PreOp (12.5% carbohydrates, 0.5kcal/mL, 240 mOsm/kg, pH 4.9) 3 hours before induction of	-BG & insulin - 4 hr. before surgery and before end of operation to measure glucose and insulin.	- VAS scores for thirst were decreased compared to the placebo (1-hour pre-op CHO group 20 (8-59), fasting group	**Preoperative oral carbohydrate drinks reduce postoperative insulin resistance and experience less hunger and thirst than patients who fasted overnight.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
Level 1	resistance after colorectal surgery.	group (n=16) investigator blinded.	anesthesia ingesting within 1 hour. **Fasting group (n=16)** fasted overnight. **Placebo group (n=16)** received 400 mL of non-carbonated, flavored water (0kcal/mL, pH 4.9) 3 hours before induction of anesthesia ingesting within 1 hour.	-Muscle biopsy taken from rectus abdominis muscle at the end of the operation to help determine protein tyrosine kinase activity (activates insulin actions). -VAS wellbeing scale at 1500 the day before surgery & 1 hour before surgery at 0800. -Insulin resistance assessed using HOMA-IR. -PTK activity determined by non-radioactive dot-blot assay.	34 (19-60), and placebo group 17 (6-53), p = .006) Hunger decreased in both CHO and placebo group compared to the fasting (1-hour pre-op CHO group 18 (7-37), fasting group 28 (13-50), and placebo group 22 (9-37), p = .041). -Median levels of HOMA-IR were significantly lower in OCH group than in the other two groups (CHO group median 17, placebo 25, fasting 27; $p <$ .001). -Median ISI for patients receiving OCH was significantly higher at the end of surgery compared to the other two groups ($p < .001$). -Median PTK activity and median PI3K and PKB mRNA levels were all significantly higher in the OCH group than in placebo and fasting groups ($p <$ .050). -Median protein levels of PI3K and PKB higher in OCH group than in the other two groups.	Preoperative oral carbohydrates are considered safe.
(Webster et al., 2014) Medline Complete Australia Level 1	Randomized, single-site, parallel group, controlled trial evaluating effects of preoperative oral carbohydrate drinks on length of stay in patients undergoing elective colorectal surgery.	44 adult patients (age 18 and up) undergoing elective colorectal surgery. Carbohydrate group (n=22) and usual care group (n=22).	**Carbohydrate-rich group (n=22)** -received 800mL of the oral carbohydrate drink (50kcal/100mL, 290 mOsm/kg, pH 5.0) between 1900 and 2400 with an additional 200mL at 0500 the day of surgery. Patients permitted no solid food	-Readiness for discharge was measured, including passing flatus, stool, and urine, eating satisfactorily, managing pain, afebrile, walking independently, wound dressing changes less than twice daily, no drains requiring inpatient management.	-No difference in mean time to readiness of discharge (4.3 vs 4.1 days, p = .824) and time to passage of first flatus. 34.7 vs 49.8h hr. -Time to first bowel movement was faster in carbohydrate group, but not statistically	Safety of preoperative carbohydrates confirmed, but results on time to discharge are inconclusive and further larger studies are recommended. **NO SIGNIFICANT DIFFERENCE**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
			after midnight. Clear fluids allowed after midnight. **Usual care group (n=22)** fasting from midnight but allowed other clear fluids during fasting period until 0500.	-Time to first flatus, first bowel movement. -Death from any cause & adverse outcomes.	significant (46.5 vs 68.4 hr; *p* = .082). -More patients in the usual care group experienced adverse events, but it was not statistically significant (*p* = .376).	
(Wongyingsinn et al., 2019) Medline Complete Thailand Level 1	Randomized controlled trial evaluating effects of preoperative oral carbohydrates on postoperative walking capacity in elective colorectal surgery.	68 adult patients aged 18-85 years undergoing elective major colorectal surgery. Carbohydrate group (n=30) and water group (n=29).	**Carbohydrate group (n=30)** -received 800 mL of a carbohydrate-rich drink (12.5g carbohydrates/100mL, 80% polysaccharides (maltodextrin), 20% monosaccharide (glucose), 50kcal/100mL, 280mOsm/kg, pH 7.0, sodium 50mmol/100mL, potassium 122mmol/100mL, chloride 13.3mmol/100mL, calcium 6mmol/100mL, phosphorus 1mmol/100mL, magnesium 1mmol/100mL) between 1900 and 2400 the night prior to surgery and an additional 400mL latest 3 hours before the induction of anesthesia. Water group (n=29) received 800mL of pure water between 1900 and 2400 the night prior to surgery and an additional 400mL of pure water latest 3 hours before the induction of anesthesia.	-Distances covered in 2-minute timed walks (2MWT) and 6-minute timed walks (6MWT). -Serum insulin and glucose prior to operation and 24 hours post-operation. -24-hour urine urea nitrogen on first three postoperative days. -LOS measured. -VAS-scale measured patient satisfaction.	No statistically significant differences observed. Carbohydrate group tended to have nitrogen balance figures that were more positive than figures of patients from the water group, especially on POD 2 and 3 (*p* = .086 and *p* = .022, respectively). Median duration of hospital stay was shorter in carbohydrate group (5.5 days vs 6; *p* = .494). Patient satisfaction higher in carbohydrate group, but no statistically significant difference (*p* = .794).	Preoperative carbohydrate drinks did not influence on supporting postoperative functional recovery when evaluated by walking performance. Further studies required. The ingestion of preoperative oral carbohydrates is considered safe. **NO SIGNIFICANT DIFFERENCE**
(Yagmurdur et al., 2011) Medline Complete	Prospective randomized controlled trial evaluating preoperative oral carbohydrate drinks	44 adult patients undergoing elective inguinal hernia repair surgery under spinal anesthesia. CHO group	**CHO group (n=22)** -received 800mL of an iso-osmolar carbohydrate-rich drink (Nutricia PreOp; 12.5% carbohydrates, 50kcal/100mL,	-Patient well-being - VAS-scale on 5 different occasions: baseline prior to operation, before intake of the morning drink, 40 minutes after the morning drink, 90 minutes	-CHO group - decreasing trends for discomfort variables of hunger (40 minutes after intake 25 vs 61; 90 minutes after intake 22 vs 69; 60 minutes after spinal anesthesia 23 vs 75,;	**Preoperative oral carbohydrates increased perioperative well-being, reducing thirst, hunger, malaise, unfitness, and anxiety.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
Turkey Level 1	on perioperative discomfort, insulin response, and arterial pressure in patients undergoing elective inguinal hernia repair surgery under spinal anesthesia.	(n=22) and control group (n=22).	290mOsm/kg, pH 5.0) and an additional 400mL 90 minutes before induction of anesthesia. **Control group (n=22)** fasted from midnight prior to the surgery.	after the morning drink, and 60 minutes after the spinal anesthesia. -Blood samples to measure blood glucose obtained before, at 40 and 90 minutes after the morning drink, and 60 minutes after spinal anesthesia.	$p < .001$),thirst (40 minutes after intake 21 vs 58; 90 minutes after intake 20 vs 60; 60 minutes after spinal anesthesia 18 vs 64; $p < .001$), malaise (40 minutes after intake 10 vs 22; 90 minutes after intake 10 vs 21; 60 minutes after spinal anesthesia 8 vs 23; $p < .05$) and unfitness (40 minutes after intake 16 vs 32; 90 minutes after intake 17 vs 32; 60 minutes after spinal anesthesia 16 vs 30; $p < .01$) during the perioperative period. -Plasma glucose & insulin concentration increased in CHO group before spinal anesthesia compared to before intake of CHO & control group ($p < .05$) -CHO group less hunger ($p < .01$), thirst ($p < .05$), malaise ($p < .001$), & unfitness ($p < .05$) at 40 & 90 minutes after the morning drink & 60 minutes after the spinal anesthesia compared with control group. -CHO group less anxious (40 minutes after intake 21 vs 50; 90 minutes after intake 20 vs 48; 60 minutes after spinal anesthesia 98 vs 75; $p < .05$) than control group at 40 and 90 minutes after morning drink. -MAP was lower in control group before and 10 and 20 minutes after spinal anesthesia compared to CHO group (10 minutes post-anesthesia 98 vs	**Preoperative oral carbohydrates improved insulin response and stabilized MAP.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
					75; 20 minutes 100 vs 80; $p <$ .05).	
(Yang et al., 2012) Medline Complete China Level 1	Randomized, double-blind, controlled trial evaluating effects and safety of preoperative oral carbohydrates in patients undergoing radical distal gastrectomy.	48 adult patients undergoing radical distal gastrectomy. CHOD group (n=24) and placebo group (n=24).	**CHOD group (n=24)** -received 500mL carbohydrate-rich drink (10% carbohydrates) 2-3 hours before induction of anesthesia, ingesting the drink within 20 minutes. Placebo group (n=24) received 500mL of a placebo-drink containing no carbohydrates.	-Blood samples collected 4 hours prior to surgery and immediately after surgery to measure plasma insulin and glucose. -HOMA-IR used to assess insulin resistance. -Postoperative complications and length of stay recorded.	Blood glucose and insulin significantly lower post-operatively in CHOD group compared to placebo group (CHO group 7.64 vs placebo group 9.32, p =.026; 16.72 vs 30.72; p = .034; respectively) HOMA-IR was significantly lower in CHOD group compared to placebo group (CHO group 5.67; placebo group 12.68; p = .003). No statistically significant difference in length of stay between the groups.	Preoperative oral carbohydrate ingestion is considered safe. **Preoperative oral carbohydrate administration lowered HOMA-IR, insulin, and blood glucose postoperatively.** No difference in length of stay.
(Yildiz et al., 2013) Medline Complete Turkey Level 1	Randomized controlled trial evaluating effect of oral CHO loading on postoperative discomfort in patients undergoing laparoscopic cholecystectomy.	60 adult patients ages 25-65 undergoing laparoscopic cholecystectomy. Study group (n=30) and control group (n=30).	**Study group/ CHO (n=30)** -received 800mL of an iso-osmolar carbohydrate-rich drink (Nutricia PreOp; 12.5% carbohydrates, 50kcal/100mL, 240 mOSm/L, pH 4.9) the night before surgery and an additional 400mL 2-3 hours preoperatively. Control group (n=30) fasted for 8 hours prior to operation.	-Patient's well-being scored using VAS-scale on five occasions: during preoperative examination night prior to surgery, prior to intake of drink 2-3 hours preoperatively, just before operation, two hours after the operation, 24 hours postoperatively. -Anxiety and depression values evaluated by Hospital Anxiety and Depression Scale after intake of liquids in the morning and the operation the day before surgery. -Fasting blood glucose measured 2-3 hours preoperatively, just before operation, and 90 minutes intraoperatively.	In the study group 2-3hr before surgery, malaise (2 vs 10), thirst (4 vs 12), hunger (0 vs 11), and weakness (5 vs 13) were found significantly lower than control group (p = .024). Just before the surgery malaise, thirst, hunger, and fatigue (p = .001). 2hr after the operation, thirst (13 vs 30), hunger (5 vs 26), and weakness (5 vs 14) were decreased in CHO ($p < .05$). 4hr after the operation, malaise and weakness were also found significantly lower than control group ($p < .05$). No statistically significant differences in nausea. Fasting blood glucose higher in control group than the study	**Preoperative oral carbohydrate administration increased patient well-being and reduces perioperative discomfort.** Preoperative oral carbohydrate administration considered safe.

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
				BP, MAP, and HR measured at bedside exam night prior, before the last drink in the morning, during preoperative monitorization, 30 minutes intraoperatively, two hours postoperatively.	group at 90 minutes intraoperatively (*p* < .05). Gastric pH (gastric acidity) values were found to be statistically significant in the study group compared with those of the control group (*p* = .0001 < .05). No difference in MAP, HR, anxiety, and depression risk.	
(Yilmaz et al., 2013) Medline Complete Turkey Level 1	Prospective, randomized, single-blind, controlled study comparing effects of carbohydrate drink with preoperative overnight fasting on gastric pH, residual volume, postoperative nausea and vomiting, and antiemetic consumption in patients undergoing laparoscopic cholecystectomy.	40 adult patients aged 18-60 undergoing elective laparoscopic cholecystectomy. Group C (n=20) and group F (n=20).	**Group C/ carbohydrate group (n=20)** -received 400mL of carbohydrate-rich drink (Nutricia PreOp; 12.5% glucose) 2 hours prior to surgery. Group F, or fasting group (n=20), fasted from midnight prior to surgery, or 8 hours.	-STAI tests used to measure anxiety. -Hemodynamic parameters recorded at induction, intubation, and every 5 minutes. -Gastric residue pH recorded. -PONV scores and vital parameters recorded in 1, 10, 15, and 30 minutes in the PACU. PONV continued to be recorded through first 24 hours post-operation.	Pre-operative anxiety higher in group F than group C (16.62 vs 24.38; *p* = .035). Residual volume and pH value had no statistically significant difference. Overall, VDS scores and antiemetic consumption was lower in group C than group F drug 24hr 13,50 vs 27,50; *p* < .001; and 24hr VDS 13,02 vs 27,98; *p* = .001; respectively). Patient satisfaction higher in group C (*p* = <.001).	**Oral carbohydrate intake increased patient well-being and reduced anxiety.** Preoperative oral carbohydrate administration considered safe. **Postoperative nausea and vomiting decreased** with preoperative oral carbohydrate administration and antiemetics were used less.
(Yuill et al., 2004) PubMed England Level 1	Randomized, double-blind clinical trial evaluating effect of preoperative carbohydrate fluid administration on postoperative metabolic and clinical responses in patients undergoing major elective upper-gastrointestinal surgery.	65 adult patients undergoing elective major upper-gastrointestinal surgery. Carbohydrate group (n=31), placebo group (n=34).	**Carbohydrate group (n=31)** -received 800mL of carbohydrate-rich drink (12.6g carbohydrates/100 ml with electrolytes; potassium, sodium, chloride, calcium, magnesium) the evening prior to surgery (around 12 hours prior) and an additional 400mL 2-3 hours before induction of anesthesia, consumed over 20 minutes.	-Nutritional assessment conducted prior to surgery and at discharge. -Plasma insulin and glucose measured preoperatively and on POD 1.	No significant difference in BMI observed postoperatively. Insulin and glucose concentrations were not statistically significant. Median length of hospital stay was 10 days in placebo group and 8 days in the carbohydrate group but was not statistically significant.	Preoperative carbohydrate fluid administration is considered safe. **Preoperative carbohydrate administration appears to attenuate depletion of muscle mass associated with the metabolic stress of surgery.**

Citation/ Database/ Country/ JH Level	Design/Objectives	Sample	Intervention/CHO Loading/Type/Amount/Dose	Outcomes Measured	Results	Conclusion/Implications
			Placebo group (n=34) received 800mL of a placebo drink (fluid and electrolytes; potassium, sodium, chloride, calcium, magnesium) the evening prior to surgery (around 12 hours prior) and an additional 400mL 2-3 hours before induction of anesthesia, consumed over 20 minutes.		Loss of muscle mass significantly greater in placebo group (-0.5 cm vs -1.1 cm; $p < .05$).	

Abbreviations: VAS-visual analog scale; BG-blood glucose; LOS-length of stay; POD-post op day: IL-1-Interleukin 1; TNF-a-tumor necrosis factor alpha; MAP-mean arterial pressure

Appendix B: Appraisal Tools

Appendix 3.3: JBI Critical appraisal Checklist for Quasi-Experimental Studies (non-randomized experimental studies)

JBI Critical Appraisal Checklist for Quasi-Experimental Studies
(non-randomized experimental studies)

Reviewer____________________________ Date____________________________

Author ____________________________ Year____________ Record Number ________

	Yes	No	Unclear	Not applicable
1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?				
2. Were the participants included in any comparisons similar?				
3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?				
4. Was there a control group?				
5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?				
6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?				
7. Were the outcomes of participants included in any comparisons measured in the same way?				
8. Were outcomes measured in a reliable way?				
9. Was appropriate statistical analysis used?				

Overall appraisal: Include Exclude Seek further info

Comments (Including reason for exclusion)

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Appendix 3.1: JBI Critical appraisal checklist for randomized controlled trials

JBI Critical Appraisal Checklist for Randomized Controlled Trials

Reviewer______________________________ Date______________________________

Author ______________________________ Year______________ Record Number ______

	Yes	No	Unclear	NA
1. Was true randomization used for assignment of participants to treatment groups?				
2. Was allocation to treatment groups concealed?				
3. Were treatment groups similar at the baseline?				
4. Were participants blind to treatment assignment?				
5. Were those delivering treatment blind to treatment assignment?				
6. Were outcomes assessors blind to treatment assignment?				
7. Were treatment groups treated identically other than the intervention of interest?				
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?				
9. Were participants analyzed in the groups to which they were randomized?				
10. Were outcomes measured in the same way for treatment groups?				
11. Were outcomes measured in a reliable way?				
12. Was appropriate statistical analysis used?				
13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?				

Overall appraisal: Include Exclude Seek further info

Comments (Including reason for exclusion)

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JBI CRITICAL APPRAISAL CHECKLIST FOR SYSTEMATIC REVIEWS AND RESEARCH SYNTHESES

Reviewer________________________________ Date________________________

Author________________________________ Year_______ Record Number_______

	Yes	No	Unclear	Not applicable
1. Is the review question clearly and explicitly stated?	☐	☐	☐	☐
2. Were the inclusion criteria appropriate for the review question?	☐	☐	☐	☐
3. Was the search strategy appropriate?	☐	☐	☐	☐
4. Were the sources and resources used to search for studies adequate?	☐	☐	☐	☐
5. Were the criteria for appraising studies appropriate?	☐	☐	☐	☐
6. Was critical appraisal conducted by two or more reviewers independently?	☐	☐	☐	☐
7. Were there methods to minimize errors in data extraction?	☐	☐	☐	☐
8. Were the methods used to combine studies appropriate?	☐	☐	☐	☐
9. Was the likelihood of publication bias assessed?	☐	☐	☐	☐
10. Were recommendations for policy and/or practice supported by the reported data?	☐	☐	☐	☐
11. Were the specific directives for new research appropriate?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

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Johns Hopkins Nursing Evidence-Based Practice
Appendix C: Evidence Level and Quality Guide

Evidence Levels	Quality Guides
Level I Experimental study, randomized controlled trial (RCT) Systematic review of RCTs, with or without meta-analysis	**A <u>High quality:</u>** Consistent, generalizable results; sufficient sample size for the study design; adequate control; definitive conclusions; consistent recommendations based on comprehensive literature review that includes thorough reference to scientific evidence **B <u>Good quality:</u>** Reasonably consistent results; sufficient sample size for the study design; some control, fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence **C <u>Low quality or major flaws</u>:** Little evidence with inconsistent results; insufficient sample size for the study design; conclusions cannot be drawn
Level II Quasi-experimental study Systematic review of a combination of RCTs and quasi-experimental, or quasi-experimental studies only, with or without meta-analysis	
Level III Non-experimental study Systematic review of a combination of RCTs, quasi-experimental and non-experimental studies, or non-experimental studies only, with or without meta-analysis Qualitative study or systematic review with or without a meta-synthesis	

Johns Hopkins Nursing Evidence-Based Practice
Appendix C: Evidence Level and Quality Guide

Evidence Levels	Quality Guides
Level IV Opinion of respected authorities and/or nationally recognized expert committees/consensus panels based on scientific evidence Includes: • Clinical practice guidelines • Consensus panels	**A** **High quality:** Material officially sponsored by a professional, public, private organization, or government agency; documentation of a systematic literature search strategy; consistent results with sufficient numbers of well-designed studies; criteria-based evaluation of overall scientific strength and quality of included studies and definitive conclusions; national expertise is clearly evident; developed or revised within the last 5 years **B** **Good quality:** Material officially sponsored by a professional, public, private organization, or government agency; reasonably thorough and appropriate systematic literature search strategy; reasonably consistent results, sufficient numbers of well-designed studies; evaluation of strengths and limitations of included studies with fairly definitive conclusions; national expertise is clearly evident; developed or revised within the last 5 years **C** **Low quality or major flaws:** Material not sponsored by an official organization or agency; undefined, poorly defined, or limited literature search strategy; no evaluation of strengths and limitations of included studies, insufficient evidence with inconsistent results, conclusions cannot be drawn; not revised within the last 5 years

Johns Hopkins Nursing Evidence-Based Practice
Appendix C: Evidence Level and Quality Guide

Level V Based on experiential and non-research evidence Includes: • Literature reviews • Quality improvement, program or financial evaluation • Case reports • Opinion of nationally recognized experts(s) based on experiential evidence	**Organizational Experience:** **A** <u>**High quality:**</u> Clear aims and objectives; consistent results across multiple settings; formal quality improvement, financial or program evaluation methods used; definitive conclusions; consistent recommendations with thorough reference to scientific evidence **B** <u>**Good quality:**</u> Clear aims and objectives; consistent results in a single setting; formal quality improvement or financial or program evaluation methods used; reasonably consistent recommendations with some reference to scientific evidence **C** <u>**Low quality or major flaws:**</u> Unclear or missing aims and objectives; inconsistent results; poorly defined quality improvement, financial or program evaluation methods; recommendations cannot be made **Literature Review, Expert Opinion, Case Report, Community Standard, Clinician Experience, Consumer Preference:** **A** <u>**High quality:**</u> Expertise is clearly evident; draws definitive conclusions; provides scientific rationale; thought leader(s) in the field **B** <u>**Good quality:**</u> Expertise appears to be credible; draws fairly definitive conclusions; provides logical argument for opinions **C** <u>**Low quality or major flaws:**</u> Expertise is not discernable or is dubious; conclusions cannot be drawn

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