Preoperative Carbohydrate Loading in Patients Undergoing Thoracic Surgery: A Quality-Improvement Project

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Purpose: *The purpose of this project was to implement carbohydrate loading in patients undergoing thoracic surgery in an effort to decrease postoperative pain, nausea, and length of stay as a part of an enhanced recovery after surgery protocol.*
Design: *This quality-improvement project used a preintervention and postintervention design.*
Methods: *Carbohydrate loading was given to 50 patients before undergoing thoracic surgery. Chart review was performed for 47 patients who received standard preoperative instructions in the preintervention group as historical control.*
Findings: *Patients who received carbohydrate loading had a decreased use of opioids in the first 4 hours after surgery (P = .028) and decreased use of antiemetic medication in the first 24 hours after surgery compared with the preintervention group (P = .066). Patients who were instructed to consume carbohydrate loading complied 87% of the time.*
Conclusions: *Carbohydrate loading can decrease postoperative nausea and pain in patients undergoing thoracic surgery.*

Keywords: *carbohydrate loading, postoperative nausea and vomiting, postoperative pain, enhanced recovery after surgery (ERAS).*

POSTOPERATIVE RECOVERY FROM thoracic surgery is a concern for patients and clinicians because of potential complications and discomfort. Patients who undergo thoracic surgery report symptoms including nausea, vomiting, pain, and a decreased sense of well-being in the perioperative period.[1] Pain associated with thoracic surgery, while very distressing to patients, is also noted to alter breathing mechanics and increase immune distress response.[2] Research and protocol changes have been made to study the metabolic and physiologic stress of surgery on the body and interventions to mitigate these effects.[3] This interprofessional quality-improvement (QI) project implemented carbohydrate loading as part of an enhanced recovery after surgery (ERAS) protocol in patients undergoing thoracic surgery to decrease pain, postoperative nausea and vomiting (PONV), and length of stay (LOS).

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Background

ERAS was partially implemented in the Thoracic and Cardiovascular Surgery Department at MD Anderson Cancer Center in 2012.[3] The surgical and anesthesia teams enacted the ERAS protocol in several phases with the goal of decreasing the LOS and complication rate in surgical patients.[4] Surgeons and researchers believe that enhanced recovery modifies the patient's stress response to surgery by returning the body's organs to normal function more quickly.[1] ERAS is achieved through a comprehensive care plan beginning with preoperative education, intraoperative techniques, and conservative postoperative pain management.[3] One aspect of the ERAS protocol that had not been enacted in our institution was preoperative carbohydrate loading.

Preoperative carbohydrate loading in patients undergoing surgery as part of the ERAS protocol has demonstrated positive outcomes including decreased LOS, decreased incidence of PONV, and decreased pain.[5-8] Traditionally, patients undergoing anesthesia are asked to remain "nil per os" (NPO) or nothing by mouth, after midnight before surgery, which is believed to decrease the risk of intraoperative or postoperative aspiration. This practice was first seen in medical textbooks in the 19th century when case studies of patients who aspirated were presented.[9] The gastrointestinal physiology of an individual without gastroparesis, diabetes mellitus, or other known conditions that may slow gastric function empties the stomach of clear liquids in approximately 90 minutes.[10] A meta-analysis was performed on 5 studies which identified that the volume of gastric content was nearly identical when comparing a shorter fast after clear liquids or carbohydrate loading to a traditional overnight fast.[10] The fasted state for patients going into surgery increases metabolic stress and makes it more difficult for patients to recover from further complications.[11]

Preoperative fasting induces stress on the body, including the loss of glycogen stores, and the body sacrifices lean muscle to meet the energy needs of the surgery. This leads to dehydration, which contributes to PONV.[1] Surgical stress leads to insulin resistance and hyperglycemia, which also contributes to PONV.[5] A top concern for patients undergoing anesthesia is PONV, which is noted to occur in 30% of all surgical patients. PONV has been described as more burdensome to patients than postoperative pain.[12,13] The lack of perioperative well-being due to anesthesia, dehydration, and nausea leads to a perceived change in pain. Increased pain leads to increased use of opioid medication in the postoperative period, which may decrease the healing process and alter gastrointestinal function.[14,15] In addition, there is an increased awareness in the medical community to attempt to curtail the use of opioid medications because of the opioid crisis.[16]

Preoperative carbohydrate loading is used to decrease the surgical stress on the body, which is augmented by fasting before surgery. Wischmeyer notes that the stress of surgery on the body exceeds that of running a marathon.[17] It is commonly known that a marathon runner would carbohydrate load before races. Runners would never fast the night before a race; however, patients are routinely asked to fast before the metabolically stressful experience of surgery.

Population

The population for this project included patients undergoing thoracic surgery, older than 18 years, and undergoing lung resection for primary lung cancer or secondary metastasis. All standard surgical approaches for lung resection were included: open thoracotomy, video-assisted thoracic surgery, and robot-assisted thoracic surgery (RATS). Patients undergoing other types of thoracic surgery were excluded. Patients who have higher risk of aspiration, including those who have undergone prior esophageal surgery, benign motility disorders of the esophagus, and who reported nausea and vomiting before surgery were excluded. There are data on the safe use of preoperative carbohydrate loading in patients with diabetes; however, for the purposes of this QI project, patients with diabetes mellitus were excluded.[5-7,18-20] Translation services were used for patients whose primary language was not English.

The sample size estimation was calculated based on the independent Student one-tailed t test, the most complex statistic used, with the power set to 0.80, which called for at least 31 patients in each group.[21] The intended sample size was 50 in the preintervention group and 50 in the

Table 1. Demographics of Surgical Patients

	Preintervention	Postintervention
Number included in analysis	47	50
A. Surgical approach		
Thoracotomy	25	33
Video-assisted thoracic surgery (VATS)	17	13
Robo-assisted thoracic surgery (RATS)	5	4
B. Lung resection		
Lobectomy	28	31
Segmentectomy	3	4
Wedge resection	16	15
C. Gender and age		
Male	22	27
Female	25	23
Average age in years (± standard deviation)	60.56 (14.24)	61.56 (13.08)

postintervention group, which allowed for attrition or missing data. χ^2 Test was used to calculate categorical variables. SPSS software (version 24, IBM, Armonk, NY) was used to perform the statistical analysis.[22]

The preintervention historical reference group included patients who underwent surgery between April and June 2018. The postintervention group included patients undergoing thoracic surgery who underwent resection between June and October 2018. The demographics, surgical approach, and extent of lung resection of patients are described in Table 1.

In the preintervention group, 50 patients were selected for chart review of the outcome measures related to the carbohydrate loading based on meeting the criteria for inclusion. Patient-controlled analgesia pain management was started on 3 patients who were excluded because retrieving the amount of opioid retrospectively was not possible during chart review. In the final analysis, 47 patients were included in the preintervention group.

In the postintervention group, 66 patients were selected to take the preoperative carbohydrate loading product. Of these patients, 9 reported that they did not take the product at home before reporting to the preoperative area. Of the 66 patients, 7 were excluded for needing to start patient-controlled analgesia for pain management. In the final analysis, 50 were included for the postintervention group.

The preintervention and postintervention groups were closely matched regarding patient demographics. Table 1 describes the average age of the patients in each group, and the number of males and females are similar. The surgical approach (thoracotomy, video-assisted thoracic surgery, or robot-assisted thoracic surgery) and extent of lung removed (wedge resection, segmentectomy, or lobectomy) are also comparable between the 2 groups.

Ethics

Approval for the project was obtained from the institutional quality improvement assessment board. Patients' consent was not deemed necessary by the quality improvement assessment board. Protected health information that would identify patients was not collected.

Design

This QI project used a preintervention and postintervention comparison in patients undergoing thoracic surgery. The preintervention group served as a historical control. All patients were assessed for pain, PONV, and LOS. The preintervention control group received usual instructions to remain NPO after midnight, with the standard ERAS protocol allowing patients to take clear liquids up to 2 hours before reporting to the preoperative holding area. The comparison, postintervention group self-administered the product Ensure Pre-Surgery Clear Nutrition Drink (Abbott, Chicago, IL) 2 hours before reporting to the

preoperative holding area. This product meets the recommendations of Enhanced Recovery After Surgery Society guidelines to contain 50 g of carbohydrates.[23]

In-service training staff meetings and education was provided to the registered nurses, advanced practice providers, anesthesiologists, and surgeons in the clinic, anesthesia assessment center, preoperative area, and postanesthesia care unit (PACU) as each area met the patient on the surgical pathway. An order was given by the advanced practice provider or surgeon for the appropriate patients to receive the carbohydrate loading product. The clinic nurse gave the patient the carbohydrate product at the preoperative appointment that was scheduled per hospital policy within 30 days of surgery. Patients were instructed to consume Ensure Pre-Surgery Clear Nutrition Drink 2 hours before arrival to the preoperative holding area.

Standard preoperative education was given to all patients to prepare for surgery. A supplemental paper handout was given to intervention patients to reinforce the use of the carbohydrate-loading product. The clinic nurse and advanced practice provider documented that the patient was an appropriate candidate for carbohydrate loading and had received the product and instructions.

The nursing informatics group added a carbohydrate loading option to the electronic medical record to document if the patient took the product and at what time. This documentation was performed with the NPO assessment when the patient checked into the preoperative area.

Outcome Measures

The number of patients receiving the carbohydrate loading product and were confirmed to consume it were recorded to assess the feasibility of the patient complying with the instructions and self-administering the product. Outcome measures included the occurrence of nausea and vomiting as a categorical value (yes/no) measured by the administration of an antiemetic medication (ondansetron or promethazine) in the first 24 hours after surgery. These data were collected from the medication administration record.

Patient-reported pain scores (0-10) were also collected from chart review in the first 4 hours postoperatively and in the first 24 hours after surgery and then averaged together. These measures were obtained during standard nursing assessments performed postoperatively and were collected from the electronic medical record. In addition, the morphine daily equivalent (MDE) was obtained from the medication administration record by calculating the use of opioid medication and converting it to an equianalgesic dose for morphine. This conversion allowed the clinician to determine the ratio of doses of different opioid medications to determine the analgesic effect.[24]

Details on hospital LOS after surgery were collected from the chart review. The time in hours to the patient meeting discharge criteria from PACU as per the American Society of PeriAnesthesia Nurses was also collected from chart review.[25]

Results

To determine the feasibility of implementing this intervention in patients undergoing thoracic surgery, fidelity to carbohydrate loading was reported as the percentage of patients who took the preoperative drink as instructed. Descriptive statistics were used to summarize these data. Of the 66 eligible patients who received the product, 57 (87%) reported that they self-administered it before arriving to preoperative check (Table 2). Of note, 7 of these 57 patients were excluded from the final analysis as earlier described because of the inability to fully collect all outcome data.

Pain was analyzed objectively by the amount of opioid medication taken by the patient and subjectively through the self-reported pain score average. This was analyzed during the first 4 hours after surgery and the first 24 hours after surgery. Group comparisons (before and after the intervention) were analyzed using a one-tailed Student *t* test for normally distributed data for the 2 independent groups. There was no difference seen in the reported average pain score between the 2 groups during the first 4 hours after surgery, or during the first 24 hours postoperatively. There was no difference seen in MDE administered in the 24 hours after surgery. There was a decrease in MDE in the postintervention group in the first

Table 2. Results

Length of Time Until Discharge Criteria From PACU Met	**Mean Time in Hours (SD)**
Preintervention	1:32:15.32 (0:35:57.04)
Postintervention	1:39:54.00 (0:45:09.83)
Independent one-tailed *t* test	$P = .178$
Length of Total Hospitalization	**Mean Time in Days (SD)**
Preintervention	3.957 (0.50)
Postintervention	4.44 (0.64)
Independent one-tailed *t* test	$P = .278$
Incidence of Nausea and Vomiting in the First 24 Hours After Surgery	**Incidence**
Preintervention	32% (15/47)
Postintervention	16% (8/50)
χ^2 Test	$P = .066$
Pain scores first 4 hours after surgery	**Mean Pain Score (SD)**
Preintervention	3.3095 (1.92)
Postintervention	3.0920 (1.80)
Independent one-tailed *t* test	$P = .282$
Pain scores first 24 hours after surgery	**Mean Pain Score (SD)**
Preintervention	2.640 (1.40)
Postintervention	2.810 (1.34)
Independent one-tailed *t* test	$P = .268$
Morphine daily equivalent first 4 hours after surgery	**Mean Amount MDE in Milligrams (SD)**
Preintervention	17.574 (19.55)
Postintervention	11.080 (12.25)
Independent one-tailed *t* test	$P = .028$
Morphine daily equivalent first 24 hours after surgery	**Mean Amount MDE in Milligrams (SD)**
Preintervention	25.128 (25.29)
Postintervention	18.800 (16.68)
Independent one-tailed *t* test	$P = .076$
Compliance with taking carbohydrate loading	**57/66 (87%)**

SD, standard deviation; MDE, morphine daily equivalent; PACU, postanesthesia care unit.

4 hours after surgery, which is statistically significant ($P = .028$) (Table 2).

Occurrence of nausea and vomiting was measured by the administration of an antiemetic medication in the first 24 hours after surgery. There was a notable decrease in the number of patients who needed antiemetic medication in the carbohydrate loading group. A χ^2 test was used for these categorical data. In the preintervention group, 15 of the 47 (32%) patients required antiemetic medication as opposed to the postintervention group, where 8 of the 50 (16%) patients required antiemetic medication. This was approaching statistical significance ($P = .066$) and is lower than the 30% nausea rate reported in the literature.[12,13] This was a major reduction in the number of patients who experienced nausea and vomiting.

The total hospitalization LOS was similar for both groups. Patients who received carbohydrate loading did not meet PACU discharge criteria

sooner than the patients who received usual care. There are several potential reasons for this. There were 2 patients in the postintervention group who had prolonged hospitalizations over 20 days because of surgical complications. However, even when excluding these 2 patients from the analysis, there was no improvement noted between the 2 groups for total LOS. In addition, both groups of patients were on the ERAS protocol and received standard interventions to decrease LOS and reduce symptoms from surgery.[3]

Discussion

There were several barriers to implementation noted. This interprofessional QI project involved several groups of people in multiple locations, including the surgical clinic, the patient's home, preoperative holding, operating room, and the inpatient hospital unit. There were many concerns among the staff in these areas about the implementation process and how it might delay or impact patient care.

There was 1 surgical case which was delayed 15 minutes because of the patient's timing of carbohydrate loading at home. The patient was scheduled as a second case for the day. The first case scheduled with the same surgeon finished quicker than expected, and the patient, who consumed carbohydrate loading, was called to the operating room early. The anesthesia team determined it was prudent to delay the case until the patient was NPO for at least 2 hours before the surgery as per ERAS guidelines. This led to concern among the team that additional cases could be delayed.

Patients were at times hesitant to take the carbohydrate loading product. This is a change from usual care and may have been different from what patients experienced in previous surgeries for themselves or their family members. In addition, if the patient was scheduled for a surgical procedure at 7:00 AM as the first case of the day, this required waking up at 3:00 AM to consume the product 2 hours before checking into the preoperative area. The logistics of this were perceived as stressful by some patients while also preparing for surgery.

There was 1 case of suspected aspiration; the patient consumed the product at 3:00 AM, with the surgery beginning at 7:00 AM. The recommended time for consumption of fluids to cease is 2 hours before surgery by the ERAS society.[26] The patient was suctioned in the operating room and did not suffer any prolonged complications. According to the chart review, the patient was coughing in the preoperative area.

Lessons Learned

There were many individuals and disciplines who had a stake in the process. The education of patients and clinicians and communication were the biggest challenges, as there were many opportunities for break down in implementing a change in practice. The project involved other disciplines that were not initially thought of, including the inpatient team.

From a nursing perspective, it was important to continue to reinforce education in the clinic to ensure that appropriate patients received the product with proper instructions. The clinic nurses were the proponents of the project as they advocated for patients who were candidates to receive carbohydrate loading. The institution and the thoracic surgery clinic were also supportive of the project as there was a cost involved in obtaining the carbohydrate loading product. The practice of carbohydrate loading as part of the ERAS protocol has been sustained with this patient population.

Limitations

The sample size was relatively small in comparison to the number of patients who undergo thoracic surgery each year. The inclusion criteria were homogenous, making it difficult to extrapolate the data for more complex thoracic surgery procedures. Patients on the ERAS protocol in the preintervention group were instructed to drink clear liquids before the arrival to the hospital for surgery check in. It was not documented what fluids these patients consumed; it may have been possible they consumed some carbohydrates that could have skewed the data. Occurrence of nausea and vomiting was measured by the administration of an antiemetic medication; it is possible that there would have been patients who did not receive medication and experienced nausea and vomiting, and that these data would not have been collected.

Conclusion

Key findings support that carbohydrate loading is a nonpharmacologic intervention that can decrease nausea and pain in patients undergoing thoracic surgery, and should be incorporated into the ERAS protocol. In our experience, implementation is feasible through consistent patient education and communication among the interprofessional team. Patients can understand the instructions for carbohydrate loading and consume the product as instructed before arriving to the surgical unit. It is prudent for providers to assess patients who are at a higher risk for complications from carbohydrate loading and to avoid using it in this group. This intervention has the capability of improving postoperative well-being, including decreased nausea and pain, without causing harm to patients.

References

1. Steenhagen E. Enhanced recovery after surgery: it's time to change practice!. *Nutr Clin Pract*. 2016;31:18-29.
2. Gerner P. Postthoracotomy pain management problems. *Anesthesiol Clin*. 2008;26:355-367. vii.
3. Van Haren RM, Mehran RJ, Mena GE, et al. Enhanced recovery decreases pulmonary and cardiac complications following thoracotomy for lung cancer. *Ann Thorac Surg*. 2018;106:272-279.
4. Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: enhanced recovery after surgery (ERAS®) society recommendations. *World J Surg*. 2013;37:259-284.
5. Yildiz H, Gunal SE, Yilmaz G, Yucel S. Oral carbohydrate supplementation reduces preoperative discomfort in laparoscopic cholecystectomy. *J Invest Surg*. 2013;26:89-95.
6. Cakar E, Yilmaz E, Cakar E, Baydur H. The effect of preoperative oral carbohydrate solution intake on patient comfort: a randomized controlled study. *J Perianesth Nurs*. 2017;32:589-599.
7. Hausel J, Nygren J, Thorell A, Lagerkranser M, Ljungqvist O. Randomized clinical trial of the effects of oral preoperative carbohydrates on postoperative nausea and vomiting after laparoscopic cholecystectomy. *Br J Surg*. 2005;92:415-421.
8. Singh BN, Dahiya D, Bagaria D, et al. Effects of preoperative carbohydrates drinks on immediate postoperative outcome after day care laparoscopic cholecystectomy. *Surg Endosc*. 2015;29:3267-3272.
9. Maltby JR. Fasting from midnight–the history behind the dogma. *Best Pract Res Clin Anaesthesiol*. 2006;20:363-378.
10. Bilku DK, Dennison AR, Hall TC, Metcalfe MS, Garcea G. Role of preoperative carbohydrate loading: a systematic review. *Ann R Coll Surg Engl*. 2014;96:15-22.
11. Ljungqvist O. ERAS–enhanced recovery after surgery: moving evidence-based perioperative care to practice. *JPEN J Parenter Enteral Nutr*. 2014;38:559-566.
12. Tramer MR. Strategies for postoperative nausea and vomiting. *Best Pract Res Clin Anaesthesiol*. 2004;18:693-701.
13. Macario A, Weinger M, Carney S, Kim A. Which clinical anesthesia outcomes are important to avoid? The perspective of patients. *Anesth Analg*. 1999;89:652-658.
14. Ondrovics M, Hoelbl-Kovacic A, Fux DA. Opioids: modulators of angiogenesis in wound healing and cancer. *Oncotarget*. 2017;8:25783-25796.
15. Zoumprouli A, Chatzimichali A, Papadimitriou S, Papaioannou A, Xynos E, Askitopoulou H. Gastrointestinal motility following thoracic surgery: the effect of thoracic epidural analgesia. A randomised controlled trial. *BMC Anesthesiol*. 2017;17:139.
16. Soelberg CD, Brown RE Jr., Du Vivier D, Meyer JE, Ramachandran BK. The US opioid crisis: current federal and state legal issues. *Anesth Analg*. 2017;125:1675-1681.
17. Castellucci M. Using nutrition counseling to help prep surgery patients for better outcomes. *Mod Healthc*, http://www.modernhealthcare.com/article/20170617/TRANSFORMATION03/170619963. Accessed February 21, 2018.
18. Noblett SE, Watson DS, Huong H, Davison B, Hainsworth PJ, Horgan AF. Pre-operative oral carbohydrate loading in colorectal surgery: a randomized controlled trial. *Colorectal Dis*. 2006;8:563-569.
19. Makuuchi R, Sugisawa N, Kaji S, et al. Enhanced recovery after surgery for gastric cancer and an assessment of preoperative carbohydrate loading. *Eur J Surg Oncol*. 2017;43:210-217.
20. Hendry PO, Balfour A, Potter MA, et al. Preoperative conditioning with oral carbohydrate loading and oral nutritional supplements can be combined with mechanical bowel preparation prior to elective colorectal resection. *Colorectal Dis*. 2008;10:907-910.
21. Faul F, Erdfelder E, Lang A-G, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. 2007;39:175-191.
22. *IBM SPSS Statistics (for Windows) [computer program]. Version 24.0*. Armonk, NY: IBM Corp; 2016.
23. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: a review. *JAMA Surg*. 2017;152:292-298.
24. Chatham MS, Dodds Ashley ES, Svengsouk JS, Juba KM. Dose ratios between high dose oral morphine or equivalents and oral methadone. *J Palliat Med*. 2013;16:947-950.
25. Godden B. Determining the appropriate location and level of care for a postanesthesia and/or postsedation patient. *J Perianesth Nurs*. 2015;30:54-57.
26. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E, et al. Guidelines for enhanced recovery after lung surgery: recommendations of the Enhanced Recovery After Surgery (ERAS(R)) Society and the European Society of Thoracic Surgeons (ESTS). *Eur J Cardiothorac Surg*. 2019;55:91-115.