Predictors of Post-Discharge Pain and Satisfaction with Pain Management after Laparoscopic Bariatric Surgery: A Prospective Cohort Study

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ABSTRACT

Background: Pain management after bariatric surgery remains challenging given the risk for analgesia-related adverse events (e.g., opioid use disorder, opioid-induced respiratory depression, and marginal ulcers). Identifying modifiable factors associated with patient-reported pain outcomes may improve quality of care.

Objective: The aim of this study was to evaluate the extent to which patient and procedural factors predict 7-day post-discharge pain intensity, pain interference, and satisfaction with pain management after bariatric surgery.

Methods: This prospective cohort study included adults undergoing laparoscopic bariatric surgery at two university-affiliated hospitals and one private clinic. Preoperative assessments included demographics, Pain Catastrophizing Scale (score range 0-52), Patient Activation Measure (low [<55.1] vs. high [≥55.1]), postoperative pain expectation (0-10), and Patient-Reported Outcomes Measurement Information System-29 (PROMIS-29) anxiety and depression scales. At 7 days post-discharge, assessments included PROMIS-29 pain intensity (0-10) and pain interference scales (41.6-75.6), and satisfaction with pain management (high [10-9] vs. lower [8-0]). Linear and logistic regression were used to assess the association of pain outcomes with potential predictors identified from literature and/or clinical expertise.

Results: 351 patients were recruited (mean age = 44 ± 11 years, BMI = 45 ± 8 kg/m^2, 77% female, 71% sleeve gastrectomy) from September 2021 to April 2022. Discharge prescriptions included opioids (100%) and acetaminophen (98%) as needed ± celecoxib (4%) around-the-clock. At 7 days post-discharge, median (IQR) patient-reported pain intensity was 2.5 (1-5), pain interference was 55.6 (52.0-61.2), and 76% of patients reported high satisfaction with pain management. Pain intensity was predicted by preoperative anxiety (β +0.04 [95%CI +0.01 to +0.07]) and pain expectation (+0.15 [+0.05 to +0.25]). Pain interference was predicted by preoperative anxiety (+0.22 [+0.11 to +0.33]), pain expectation (+0.47 [+0.10 to +0.84]) and age (-0.09 [-0.174 to -0.003]). Lower satisfaction was predicted by low patient activation (OR 1.94 [1.05 to 3.58]), higher pain catastrophizing (1.03 [1.003 to 1.06]), 30-day complications (3.27 [1.14 to 9.38]) and age (0.97 [0.948 to 0.998]).

Conclusion: This study supports that patient-related factors are important predictors of post-discharge pain outcomes after laparoscopic bariatric surgery. Our findings highlight the value of addressing educational, psychological, and coping strategies to improve postoperative pain outcomes.

RÉSUMÉ

Introduction : Le traitement de la douleur après une chirurgie bariatrique demeure difficile en raison du risque d'événements indésirables liés à l'analgésie (p. ex. trouble de consommation d'opiacés, dépression respiratoire induite par les opioïdes, ulcères marginaux). L'identification des facteurs de risques modifiables associés avec des résultats de la douleur rapportés par les patients pourrait améliorer la qualité de soins.

Objectif : Le but de cette étude était d'évaluer dans quelle mesure les facteurs liés au patient et à la procédure prédisent l'intensité de la douleur, l'interférence de la douleur, et la satisfaction avec le traitement de la douleur 7 jours après la sortie de l'hôpital suite à une chirurgie bariatrique.

Méthodes : Cette étude d'une cohorte prospective inclut des adultes subissant une chirurgie bariatrique par laparoscopie dans deux hôpitaux universitaires et une clinique privée. Les évaluations préopératoires comprenaient des données démographiques, l'Échelle de Catastrophisation de la Douleur (score de 0 à 52), la Mesure de l'Activation du Patient (faible [<55.1] vs. élevé [≥55.1]), l'attente de la douleur postopératoire (0-10) et les échelles d'anxiété et de dépression du Patient-Reported Outcomes Measurement Information System-29 (PROMIS-29). Sept jours après la sortie de l'hôpital, les évaluations comprenaient l'intensité de la douleur (0-10) et l'échelle d'interférence de la douleur (41.6-75.6) de PROMIS-29, ainsi que la satisfaction à l'égard du traitement de la douleur (élevée [10-9] contre faible [8-0]). Des régressions linéaires et logistiques ont été utilisées pour évaluer l'association des résultats de la douleur avec les prédicteurs potentiels identifiés à partir de la littérature et/ou de l'expertise clinique.

Résultats : 351 patients ont été recrutés (âge moyen = 44 ± 11 ans, IMC = 45 ± 8 kg/m^2, 77% de femmes, 71% sleeve gastrectomie) de septembre 2021 à avril 2022. Les prescriptions de sortie comprenaient des opioïdes (100%) et de l'acétaminophène (98%) au besoin ± célécoxib (4%) 24 heures sur 24. Sept jours après la sortie de l'hôpital, l'intensité médiane (IQR) de la douleur rapportée par les patients était de 2.5 (1-5), l'interférence de la douleur était de 55.6 (52.0-61.2), et 76% des patients se sont déclarés très satisfaits du traitement de la douleur. L'intensité de la douleur a été prédite par l'anxiété préopératoire (β +0.04 [95%CI +0.01 à +0.07]) et l'attente de la douleur (+0.15 [+0.05 à +0.25]). L'interférence de la douleur a été prédite par l'anxiété préopératoire (+0.22 [+0.11 à +0.33]), l'attente de la douleur (+0.47 [+0.10 à +0.84]) et l'âge (-0.09 [-0.174 à -0.003]). Une satisfaction moindre a été prédite par

une faible activation du patient (OR 1.94 [1.05 à 3.58]), une plus grande catastrophisation de la douleur (1.03 [1.003 à 1.06]), des complications à 30 jours (3.27 [1.14 à 9.38]) et l'âge (0.97 [0.948 à 0.998]).

Conclusion : Cette étude supporte que les facteurs liés au patient sont des prédicteurs importants de la douleur après la sortie de l'hôpital suite à une chirurgie bariatrique laparoscopique. Nos résultats soulignent l'importance d'aborder les stratégies éducatives, psychologiques et d'adaptation pour améliorer les résultats de la douleur postopératoire.

STATEMENT OF ORIGINALITY

The work presented in this thesis represents an original contribution which adds to the body of knowledge on postoperative pain management. While I have received support from my supervisor, Research Advisory Committee members, and manuscript co-authors, the data presented in the following chapters represent my original work.

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PREFACE & CONTRIBUTION OF AUTHORS

This manuscript-based thesis reports the following study:

1. Maxime Lapointe-Gagner, BSc, Shrieda Jain, BSc; Naser Alali, MD; Hiba Elhaj, MSc; Anne-Sophie Poirier, BSc; Pepa Kaneva, MSc; Mohsen Alhashemi, MD; Lawrence Lee, MD, PhD; Raman Agnihotram, PhD; Liane S Feldman, MD; Michel Gagner, MD; Amin Andalib, MD; Julio F Fiore Jr, PhD. **Predictors of Post-Discharge Pain and Satisfaction with Pain Management after Laparoscopic Bariatric Surgery**. Published in Surgical Endoscopy on July 25, 2023 (Online ahead of print). DOI: 10.1007/s00464-023-10307-3.

Maxime Lapointe-Gagner helped design the study, recruited participants, collected and analyzed the data, and prepared the manuscript and thesis submissions. **Shrieda Jain** helped design the study, recruited participants, collected the data and reviewed drafts of the manuscript. **Naser Alali**, **Hiba Elhaj** and **Anne-Sophie Poirier** collected data and reviewed drafts of the manuscript. **Pepa Kaneva** coordinated the ethics approval for the study, prepared the protocol, and reviewed drafts of the manuscript. **Raman Agnihotram** supervised data analysis and reviewed drafts of the manuscript. **Mohsen Alhashemi**, **Lawrence Lee**, **Liane Feldman**, **Michel Gagner** and **Amin Andalib** helped design the study, supervised recruitment and data collection, and reviewed drafts of the manuscript. **Julio Fiore Jr.** designed the study, prepared the protocol, supervised recruitment, data collection and analysis, and reviewed all drafts of the manuscript.

Maxime Lapointe-Gagner presented this work at the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) annual conference in Montreal, Quebec on April 1st, 2023.

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LIST OF ABBREVIATIONS

APS: American Pain Society

APS-POQ-R: Revised American Pain Society Patient Outcome Questionnaire

ASA: American Society of Anesthesiologists

BMI: Body Mass Index

BPD-DS: Biliopancreatic Diversion with Duodenal Switch

BPI: Brief Pain Inventory

CPAP: Continuous Positive Airway Pressure

ERAS: Enhanced Recovery After Surgery

IASP: International Association for the Study of Pain

IFSO: International Federation for the Surgery of Obesity and Metabolic Disorders

IQR: Interquartile Range

LRYGB: Laparoscopic Roux-En-Y Gastric Bypass

LSG: Laparoscopic Sleeve Gastrectomy

MUHC: McGill University Health Center

OIRD: Opioid-Induced Respiratory Depression

OR: Odds Ratio

OSA: Obstructive Sleep Apnea

PACU: Post-Anesthesia Care Unit

PAM: Patient Activation Measure®

PCS: Pain Catastrophizing Scale

POD: Postoperative Day

POU: Persistent Opioid Use

PRO: Patient-Reported Outcome

PROMIS-29: Patient-Reported Outcomes Measurement Instrument System 29

REB: Research Ethics Board

MICE: Multiple Imputation By Chained Equations

MUHC: McGill University Health Center

NRS: Numeric Rating Scale

NSAID: Non-Steroidal Anti-Inflammatory Drug

RCT: Randomized Controlled Trial

REDCap: Research Electronic Data Capture

SAGES: Society of American Gastrointestinal and Endoscopic Surgeons

SADI: Single-Anastomosis Duodeno-Ileal Bypass

SD: Standard Deviation

SG: Sleeve Gastrectomy

SOS: Swedish Obese Subjects Study

STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

TAP: Transversus Abdominis Plane

T2D: Type-2 Diabetes

VAS: Visual Analogue Scale

VRS: Verbal Rating Scale

CHAPTER 1: INTRODUCTION

1.1 Obesity and bariatric surgery

The World Health Organization (WHO) classifies obesity as a chronic disease characterized by excess adiposity and a Body Mass Index (BMI) over 30 kg/m^2 presenting a risk to one's health [1, 2]. Obesity is further subdivided into Classes I (BMI of 30 to < 35), II (BMI of 35 to < 40) and III (BMI > 40) [3]. Importantly, obesity is associated with an increased risk of a broad range of chronic morbidities (i.e., type-2 diabetes [T2D], hypertension, dyslipidemia, obstructive sleep apnea [OSA], depression, anxiety) and all-cause mortality [4-6].

Since the 1980s, the prevalence of obesity has more than doubled worldwide, becoming a significant international health issue [7]. In Canada, approximately 1 in 4 (26.7%) adults are obese [8]. In the absence of large-scale interventions or treatments to curb increasing obesity rates, the prevalence of obesity in Canada is expected to rise to one-third of adults over the next decade [9, 10]. While rising obesity rates have been attributed to a complex interplay of behavioral, environmental, economic, and genetic factors, key factors exacerbating the "obesity epidemic" are the worsening of diet quality and an increasingly sedentary lifestyle [8, 11-14].

Bariatric surgery, or weight-loss surgery, is an established treatment for obesity and weight-related comorbidities [15-17]. With nearly one million procedures performed worldwide every year, bariatric procedures represent an increasingly significant proportion of major surgical procedures [18]. Given their established efficacy and safety profiles, Laparoscopic Sleeve Gastrectomy (LSG) and Roux-En-Y Gastric Bypass (LRYGB) account for over 87% of bariatric procedures around the world [18]. For the majority of patients, LRYGB and LSG result in significant weight loss as well as partial or complete resolution of associated comorbidities, including T2D, hyperlipidemia, hypertension, and OSA [19].

Evidence supports that conservative, non-surgical treatments for obesity such as dieting, physical activity, medication, or a combination thereof commonly result in weight regain and non-resolution of comorbidities [20-22]. In fact, a recent randomized controlled trial (RCT) of 61 patients with 5-year follow-up by Courcoulas et al. demonstrated remission of T2D in 30% of participants and a mean 25% weight-loss following LRYGB, compared

with no remission of T2D and 5% weight-loss after bi-monthly counseling and prescribed daily exercise [23]. Population-level data from Scandinavia demonstrated that, compared to non-surgical patients, those undergoing bariatric surgery use significantly fewer lipid-lowering (44.6% vs. 17.6%), antidiabetic (54.2% vs. 23.5%) and cardiovascular medications (83.3% vs. 74.6%) 15 years after surgery [24]. Data from the Swedish Obese Subjects (SOS) study, initiated in 1987, suggest that these benefits persist for as much as 20 years postoperatively [25, 26]. Bariatric surgery is therefore considered the most effective treatment for obesity and weight-related comorbidities [18].

1.2 Postoperative pain

With over 300 million surgical procedures performed worldwide each year (including over 800,000 bariatric procedures), postoperative pain management remains an important area of quality improvement with significant implications on patients' health and well-being [27-29]. The International Association for the Study of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" [30]. As major surgery involves extensive tissue damage, typically requiring long periods of recovery, postoperative pain is one of patients' greatest fears surrounding surgery [31, 32]. Although surgical techniques and pain management protocols have significantly advanced in the past two decades, studies suggest that the prevalence and severity of postoperative pain have only marginally improved over the same period. It is estimated that as much as 66% of patients undergoing major surgery experience moderate-to-extreme acute postoperative pain, compared to 86% of patients 20 years ago (although rates significantly vary by procedure, method and timing of assessment) [33-37].

Acute postoperative pain lasts approximately one week after surgery, but if inadequately managed, it can prolong recovery, decrease quality of life, and develop into chronic pain [38, 39]. Following bariatric surgery, acute postoperative pain remains an important issue as evidence suggests that 50-75% of patients experience moderate-to-severe pain after undergoing a bariatric procedure [40, 41]. Importantly, acute abdominal pain is one of the primary causes of emergency department visits and hospital readmission in this population [42-44]. As with any major surgical procedure, effective pain management after bariatric surgery aims to prevent these undesirable outcomes while ensuring a swift and satisfactory postoperative recovery [45].

1.3 Perioperative care and pain management after bariatric surgery

Enhanced Recovery After Surgery (ERAS) protocols aim to minimize surgical stress and optimize factors delaying surgical recovery, including postoperative pain [46, 47]. ERAS guidelines vary by surgery type but typically recommend preoperative education, minimally invasive surgery, and multimodal analgesia, among other targeted interventions [48, 49]. ERAS guidelines for bariatric surgery include procedure-specific strategies, such as preoperative weight-loss to reduce liver volume, postoperative continuous positive airway pressure (CPAP) support in patients suffering from OSA, and postoperative vitamin and mineral supplementation to reduce the risk of nutritional deficiencies [50-52]. Compared to traditional perioperative care, ERAS protocols have demonstrated notable improvements in postoperative outcomes after bariatric surgery, including significantly reducing length of stay, complication rates and costs, as well as reducing postoperative pain and opioid requirements [53-55].

Multimodal analgesia is a key component of ERAS programs and the current gold standard for postoperative pain management after bariatric surgery [50, 51]. This approach is based on the premise that, by acting on the multiple receptors and pathways involved in pain processing, the concomitant use of two or more classes of different analgesics (i.e., acetaminophen, nonsteroidal anti-inflammatory drugs [NSAIDs], local anesthetics, and opioids) can provide greater pain relief and limit the side effects of single analgesics [56, 57]. One of the primary aims of multimodal analgesia is to reduce the reliance on opioid analgesics which carry undesirable side effects (i.e., nausea, vomiting, constipation, sedation) as well as risk of addiction and overdose [58]. This is particularly relevant given the current opioid crisis in North America, which has been exacerbated by postoperative opioid overprescription [59].

Patients undergoing bariatric surgery may be at an increased risk of opioid-related harms compared to other surgical populations [60]. It is estimated that 4 to 12% of all opioid-naive patients undergoing bariatric surgery continue to use opioids beyond 3 months postoperatively [61]. This continued use of opioids is associated with a significant decline in health status, higher healthcare costs, and an increased risk of overdose and death [62, 63]. Evidence supports that chronic pain (e.g., joint or lower back pain), mental health disorders (e.g., depression, anxiety) and impulse control deficits commonly present in this population are among the primary risk factors for persistent opioid use after bariatric surgery [64, 65].

Anatomical changes of the digestive system leading to altered pharmacokinetics and increased opioid absorption are also believed to be relevant contributors [66]. Importantly, the high incidence of OSA among bariatric patients (77%) increases the risk of fatal opioid-induced respiratory depression (OIRD) [67-69]. This risk is even greater in patients with undiagnosed OSA [70]. While non-steroidal anti-inflammatory drugs (NSAIDs) are commonly used in multimodal analgesia regimens offered to surgical patients, certain guidelines discourage the prescription of NSAIDs after bariatric surgery given the potential risk for marginal ulcers and anastomotic leaks [71, 72]. Such recommendations limit the analgesic options available to bariatric patients and may exacerbate the overprescription and subsequent overuse of opioids. Taken together, the challenges described above highlight a crucial need to optimize opioid-sparing multimodal analgesia after bariatric surgery [56, 73].

1.4 Postoperative pain assessment

Pain is inherently difficult to assess due to its complex and subjective nature [74]. Consequently, the use of valid, reliable and sensitive tools is necessary for understanding patients' pain experience and evaluating the effectiveness of pain management interventions [75]. Acute pain intensity is typically measured using the patient-reported Numerical Rating Scale (NRS, 0 [no pain] to 10 [worst pain imaginable]) or Visual Analogue Scale (VAS, 0 [no pain] to 100 mm [worst pain imaginable]). On these scales, scores less than 3 (NRS) or 33 mm (VAS) generally indicate 'tolerable pain' [76, 77]. Alternatively, verbal rating scales (VRS) enable patients to describe their pain using responses such as 'Mild,' 'Moderate,' or 'Extreme pain,' which is more amenable for patients with cognitive difficulties [78]. Other methods to assess pain include the use of facial expression (e.g., Wong-Baker FACES Pain Rating Scale) or indirect physiological markers (e.g., C-Reactive Protein, heart rate variability), although these are indirect proxies of one's pain experience [75, 79-81]. Ultimately, however, NRS and VAS scores are the most commonly used in research and in practice due to their relative ease of measurement and interpretation [75].

Despite their widespread use, NRS and VAS scales are inherently limited in scope, measuring only the respondent's overall pain intensity (most often, the pain felt specifically at the time of answering) [82]. This unidimensional view of pain was challenged by Melzack & Casey who, in 1968, deemed pain as a multidimensional experience involving sensory-discriminative (i.e., intensity, location, quality), affective-motivational (i.e., influence of anger, fear and anxiety), and cognitive-evaluative components (i.e., influence of previous

knowledge and experiences) [83, 84]. Following the biopsychosocial understanding of medicine in 1977, cultural, spiritual and social influences were also acknowledged in literature to influence one's pain experience [74, 85]. Thus, pain is now recognized as a holistic and multidimensional experience, with current guidelines advising that it be measured and treated as such [86, 87]. To address the complexity of pain experiences, multidimensional measures such as the Brief Pain Inventory (BPI) or Patient-Reported Outcomes Measurement Instrument (PROMIS) were developed for patients to more comprehensively describe their pain experience, capturing the extent to which pain interferes with their daily lives and activities [88, 89]. Pain interference, or "pain impact," refers to the extent to which pain interferes with physical, cognitive, emotional, and recreational activities, as well as sleep and enjoyment of life [90]. Such multidimensional pain measures offer important insight on one's return to independence and resolution of symptoms, which are meaningful outcomes for surgical patients [91].

Ultimately, the goal of postoperative pain management is to ensure satisfactory pain relief [45]. Therefore, to improve surgical care, many quality improvement initiatives have focused on optimizing analgesia to improve satisfaction with postoperative pain management [34, 35, 92]. Patient satisfaction is generally measured using continuous numeric rating scales from 0 (Extremely Dissatisfied) to 10 (Extremely Satisfied) (e.g., "Mark the one number that best shows how satisfied you are with the results of your pain treatment") or categorical Likert scales (e.g., very dissatisfied, dissatisfied, satisfied, and very satisfied) [93, 94]. Studies support that satisfaction not only serves as an important indicator of quality of care, but is also associated with increased treatment compliance and improved outcomes [95, 96]. As there are concerns that reducing the prescription of opioids after surgery may reduce patient satisfaction, assessing satisfaction with pain management can provide relevant insights to inform prescribing practices and mitigate postoperative opioid-related harms [97-99].

1.5 Research gap

Compared to other surgical populations, pain management after bariatric surgery remains challenging due to an increased risk of analgesia-related adverse events (e.g., persistent opioid use, opioid-induced respiratory depression, marginal ulcers). Despite the need to minimize these risks while ensuring effective postoperative pain management, there is a lack of studies assessing if patient and care characteristics are associated with postoperative pain outcomes after bariatric surgery (i.e., pain intensity, pain interference and

satisfaction with pain management). We hypothesize that potentially modifiable patient- and care-related factors can predict postoperative pain outcomes and inform future quality improvement initiatives.

1.6 Thesis objectives

Considering the research gaps described above, the objective of this thesis project is to evaluate the extent to which patient and care characteristics are associated with 7-day post-discharge pain intensity, pain interference, and satisfaction with pain management after bariatric surgery.

CHAPTER 2: MANUSCRIPT

Predictors of Post-Discharge Pain and Satisfaction with Pain Management after Laparoscopic Bariatric Surgery: A Prospective Cohort Study

Article type: Observational study (cohort study)

Short running head: Predicting postoperative pain outcomes.

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2.1 Introduction

Bariatric surgery is the most effective treatment for obesity and related comorbidities [1]; however, variations in perioperative care and outcomes remain a target for quality improvement [100-102]. Acute postoperative pain is one of the leading causes of emergency department utilization after bariatric surgery and can delay recovery, decrease quality of life, or develop into chronic pain if undertreated [36, 103, 104]. Although advances in minimally invasive surgery techniques and enhanced recovery protocols aim to improve pain outcomes, studies support that 50-75% of patients undergoing bariatric surgery continue to experience moderate-to-severe pain postoperatively [40, 41]. For this reason, the importance of further research to improve pain management after bariatric surgery cannot be overstated.

Compared to other surgical populations, pain management after bariatric surgery is challenging due to unique patient characteristics and procedure-related factors that may increase the risk of analgesia-related adverse events [105]. Opioids remain a mainstay for postoperative analgesia; however, given the current opioid crisis, there has been increasing attention to the risk of opioid misuse and dependence among bariatric patients [65]. A recent meta-analysis supports that 4 to 12% of all opioid-naïve patients undergoing bariatric surgery continue to use opioids beyond 3 months postoperatively [61]. This may be partially attributed to impulse control deficits commonly present in morbidly obese patients which predisposes them to opioid misuse and the development of substance use disorder [106]. Notably, the high prevalence of obstructive sleep apnea (77%) renders bariatric patients susceptible to fatal overdoses due to opioid-induced respiratory depression [69, 107]. To reduce postoperative opioid exposure, multimodal analgesia including non-steroidal anti-inflammatory drugs (NSAIDs) have been used in many surgical settings; however, this approach has been discouraged by bariatric care guidelines given a potential risk for marginal ulcers after gastric bypass [71]. Such recommendations limit the analgesic options available to bariatric patients and may exacerbate the over-prescription of opioids.

Given this scenario, there is a dire need to minimize analgesia-related adverse events after bariatric surgery while ensuring effective postoperative pain management. Therefore, the aim of this study was to evaluate the extent to which patient and care characteristics are associated with 7-day post-discharge pain intensity, pain interference, and satisfaction with pain management after bariatric surgery. We hypothesized that potentially modifiable patient-

and procedural-related factors can predict postoperative pain outcomes and inform future quality improvement initiatives.

2.2 Materials and Methods

This was a nested study of secondary outcomes from a multicenter cohort study focused on rates of prescription and consumption of opioids after bariatric surgery [108]. Reporting is in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement (checklist available in Supplementary Table S1) [109]. Institutional review board approval was granted to conduct the study at the participating institutions (MUHC REB ref:# 2021-7699, McGill University REB ref: A07-E36-21B [21-07-076]) and all patients provided informed written consent.

2.2.1 Study population

We included adult patients (≥ 18 years) undergoing laparoscopic bariatric surgery (primary, second-stage, or revisional) between September 2021 and April 2022 at two university-affiliated hospitals and one private surgical clinic in Montreal, Canada. Patients were excluded if they had (1) a concomitant major (non-bariatric) surgical procedure other than hernia repair or cholecystectomy, (2) a condition that could interfere with informed consent or patient-reported outcome assessment (e.g., cognitive impairment, inability to understand English or French), (3) underwent a second, non-bariatric surgical procedure within the follow-up period or (4) had difficulty to be reached postoperatively (i.e., limited access to a telephone or computer).

All participants received care according to Enhanced Recovery After Surgery (ERAS) Society recommendations, including preoperative patient education (i.e., setting expectations), early mobilization (ambulation on postoperative day [POD] 0), early oral intake (liquids on POD 0, pureed/fluid diet on POD 1), and multimodal analgesia (opioid and non-opioid analgesics) [50, 51, 110]. Peripheral nerve blocks (i.e., transversus abdominis plane [TAP]) were performed at the discretion of the surgeon or anesthesiologist. The transition from intravenous to oral analgesia was done upon tolerance of oral intake; use of epidural analgesia was not part of the pathway. At the hospital sites, discharge was targeted for POD 1, with same-day discharge possible for eligible patients [111]. At the private clinic, home discharge was targeted for POD 2 following an overnight stay in the post-anesthesia care unit (PACU) and a one-night stay at a hotel with around-the-clock nurse supervision.

2.2.2 Data collection

Data regarding participant, surgery, and perioperative care characteristics were obtained from electronic and/or paper medical records. Preoperative and postoperative patient-reported data were obtained using online surveys administered through a secure REDCap platform (https://www.project-redcap.org/). Links to the online surveys were sent to participants by email or text messages and completed via smartphone, tablet, or computer. Participants were asked to complete the survey within a 24-hour window and reminded twice in case of no response. Those with limited digital technology skills or access completed the surveys via telephone interviews. Participants were contacted by telephone or e-mail to clarify missing or unclear responses.

2.2.3 Outcomes of interest

The co-primary outcomes of interest were 7-day post-discharge pain intensity, pain interference with daily activities, and satisfaction with pain management. Focus on these outcomes aligns with current recommendations that pain assessment should reflect patients' holistic and multidimensional pain experience [87]. Pain intensity and pain interference were measured using the Patient-Reported Outcomes Measurement Information System 29 (v2.0) (PROMIS-29®), a validated, generic patient-reported health measure proposed by the US National Institutes of Health [112, 113]. To measure pain intensity, respondents were asked to report their average pain in the past 7 days on a numerical rating scale (NRS) from 0 (no pain) to 10 (worst imaginable pain). Previous literature supports that pain intensity scores ≤ 3 are deemed to be 'tolerable' [76]. To measure pain interference, respondents were asked 4 questions focused on pain interference with activities in the past 7 days (e.g., "How much did pain interfere with work around the home?"), with responses ranging from "Not at all" to "Very much". Raw pain interference scores were summed and converted to a standardized T-score, where a score of 50 represents the US population mean with a standard deviation of 10 (score range 41.6-75.6, with higher scores corresponding to more pain interference) [111, 113]. Pain interference T-scores are to be interpreted as normal (41.6-55.0), mild (55.1-60.0), moderate (60.1-70.0) or severe (70.1-75.6) [114].

Satisfaction with pain management was measured on a NRS from 0 (Extremely Dissatisfied) to 10 (Extremely Satisfied) ("Mark the one number that best shows how satisfied you are with the results of your pain treatment at home, after hospital discharge"), based on the Revised American Pain Society Patient Outcome Questionnaire (APS-POQ-R)

[93]. In line with previous literature, we dichotomized satisfaction as 'High' (score ≥ 9) and 'Lower' (≤ 8) due to the highly skewed distribution of scores towards 9 and 10 [115].

2.2.4 Potential predictors

Potential predictors of post-discharge pain outcomes were selected based on findings from previous literature and/or clinical reasoning [116]. We considered the following demographic characteristics as potential predictors: age [117], sex [118], Body Mass Index (BMI) [119], American Society of Anesthesiologists (ASA) score (dichotomized as ≤ 2 and ≥ 3) [120], and race (self-reported from 8 categories and dichotomized as White or non-White due to the small number of participants within non-White groups) [121, 122]. Patient-reported preoperative measures considered as potential predictors were: anxiety (PROMIS-29; scale range 40.3-81.6) and depressive symptoms (PROMIS-29; scale range 41.0-79.4), [123, 124], pain catastrophizing (Pain Catastrophizing Scale; scale range 0-52) [125, 126], engagement in healthcare (Patient Activation Measure®, dichotomized as low [≤ 55.1] vs high [> 55.1] activation) [127, 128], preoperative chronic pain lasting more than 3 months (yes/no; question adapted from the International Pain Outcomes Questionnaire) [129, 130], and expectation of postoperative pain (NRS 0-10) [131]. Procedural factors considered were: type of surgery (dichotomized as sleeve gastrectomy [SG] vs. anastomotic procedures (including Roux-en-Y Gastric Bypass [RYGB], Single-Anastomosis Duodenal-Ileal Bypass [SADI] and Bilio-Pancreatic Diversion with Duodenal Switch [BPD-DS]) [132], concomitant procedures (hernia repair or cholecystectomy, dichotomized as yes/no) [133], administration of TAP block (yes/no) [134], number of opioid pills prescribed at discharge [135], and diagnosis of complications requiring medical intervention within 30 days of discharge (yes/no) [136-138]. Complications were assessed beyond the period of survey follow-up (7 days) to account for complications not yet diagnosed at the time of assessment (definitions available in Supplementary Table S2).

2.2.5 Sample size

This study comprised the analysis of secondary outcomes from a cohort study originally powered with a sample of 350 participants to detect a rate of unused opioids of 70% at 30 days [138] considering a margin of error of 5%, confidence interval of 99%, and attrition rate of ~10%. In the present nested study, a sample of 350 participants provides sufficient power to accommodate linear regression models for pain intensity and pain interference with 23 variables (conservatively accounting for 15 subjects per variable) [139,

140]. Moreover, this sample size provides sufficient power to accommodate up to 8 variables in a logistic regression model focused on the risk of lower satisfaction (accounting for 10 subjects per event, considering an outcome rate of ~15%) [141].

2.2.6 Statistical analysis

Descriptive statistics concerning demographics, perioperative care, surgery characteristics, and postoperative outcomes were calculated using mean (± standard deviation [SD]) or median (interquartile range [IQR]) for continuous variables, and frequency (%) for categorical variables. We used linear regression models to identify independent predictors of 7-day pain intensity and pain interference. Independent predictors of lower satisfaction with pain management (score ≤ 8) were identified using a logistic regression model [115]. In all models, we used a stepwise backward variable selection approach, retaining variables with p-value <0.1 [142]. To minimize attrition bias arising from missing data, we performed multiple imputations by chained equations (MICE) and predictive mean matching based on demographics, surgical data, and responses to non-missing postoperative questionnaires [142]. Estimates from 50 imputed datasets were combined using Rubin's rules [144]. To further assess the robustness of our results focused on patient satisfaction, we conducted sensitivity analyses (1) changing the cut-off for low satisfaction with pain management from < 9 to < 8 and (2) analyzing participant satisfaction as a continuous variable (scale 0-10) [145]. A p-value of < 0.05 was considered statistically significant. All statistical analysis was performed using Stata® version 17 (StataCorp, College Station, TX, USA).

2.3 Results

A total of 351 participants were recruited and included in the analysis. Figure 1 describes the flow of participant recruitment and reasons for non-participation. At 7-days post-discharge, 312 participants (88%) completed all the follow-up questionnaires (12% missing data were addressed using multiple imputations). Table 1 describes participants' baseline characteristics. The mean age of participants was 44.4 ± 10.7 years old and pre-operative BMI was 45.2 ± 8.0 kg/m^2. Most participants were female (n=271, 77%), White (n=266, 76%), and had ASA ≤ 2 (n=197, 56%). Before surgery, 37% of participants reported experiencing chronic pain for ≥ 3 months. Participants expected an average postoperative pain level of 5.7 ± 2.4 (out of 10) and scored 10.5 ± 10.5 (out of 52) on the Pain Catastrophizing Scale. Most participants (n=252, 73%) had high patient activation (score ≥

55.1) as measured using the Patient Activation Measure®. Median preoperative depression and anxiety levels, as measured using PROMIS-29, were 58 (out of 81.6) and 51.8 (out of 79.4), respectively.

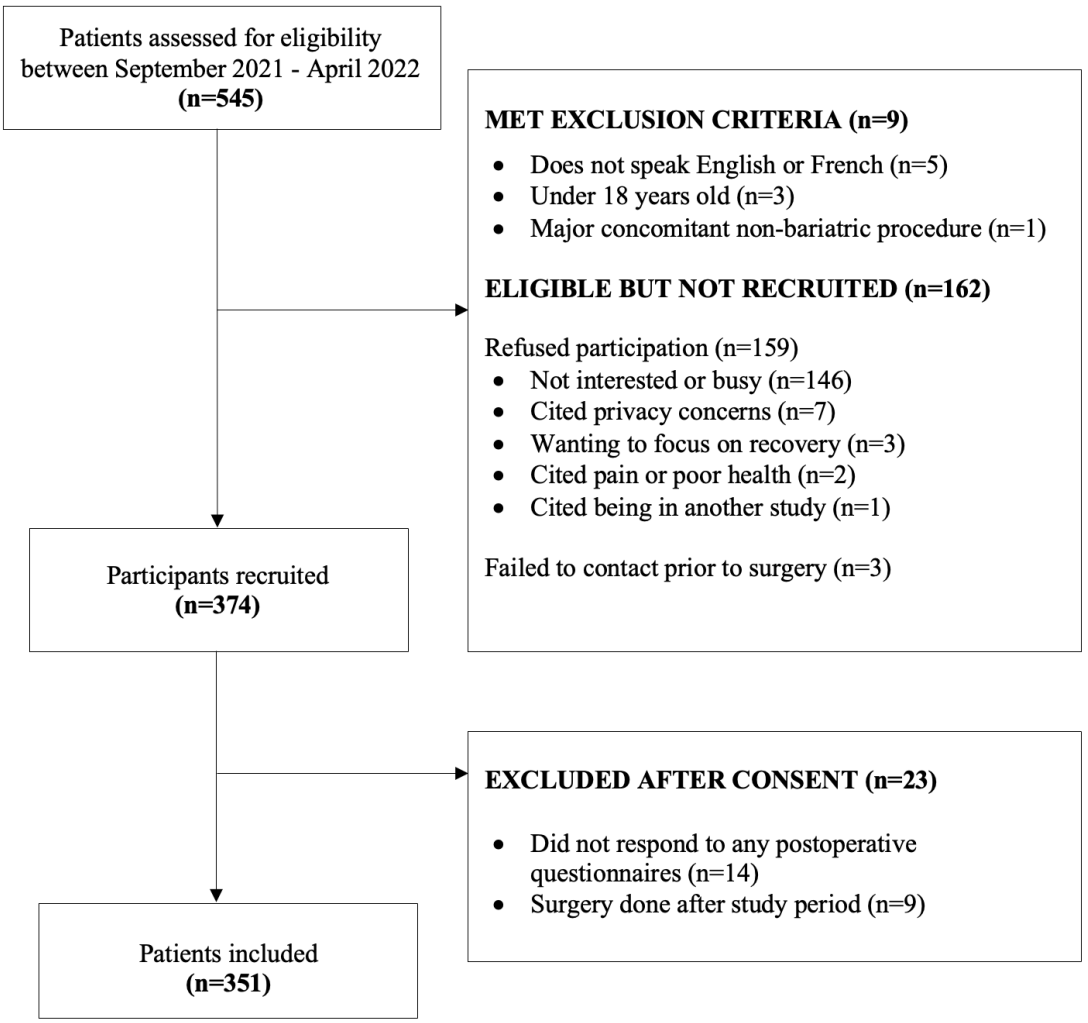

Figure 1. Participant Flowchart

Table 1 Patient baseline and surgery characteristics

Demographics	
Age (years), mean ± SD	44.4 ± 10.7
Sex	
Female	271 (77.2%)
Male	80 (22.8%)
Preoperative BMI (kg/m^2), mean ± SD	45.2 ± 8.0
ASA score	
≤ 2	197 (56.1%)
≥ 3	154 (43.9%)
Race	
White	266 (75.8%)
Non-White	59 (16.8%)
Black	27 (7.7%)
Middle Eastern	23 (6.5%)
Latino	10 (2.8%)
Asian	7 (2.0%)
Indigenous	6 (1.7%)
Not represented, unsure or missing	26 (7.4%)
Preoperative patient-reported measures	
Chronic pain (≥ 3 months before surgery)	127 (36.2%)
Pain Catastrophizing Scale, mean ± SD	10.5 ± 10.5
Pain Expectation, mean ± SD	5.7 ± 2.4
Patient Activation Measure	
Low (1-2)	91 (26.5%)
High (3-4)	252 (73.5%)
PROMIS-29 Anxiety, median (IQR)	57.7 (51.2 - 61.4)
PROMIS-29 Depressive Symptoms, median (IQR)	51.8 (41.0 - 57.3)

Table 1 Patient baseline and surgery characteristics

Surgical characteristics	
Main surgical procedure type	
Sleeve Gastrectomy [a]	249 (70.9%)
Roux-En-Y Gastric Bypass	75 (21.4%)
Other anastomotic procedures [b]	27 (7.7%)
Concomitant procedure	78 (22.2%)
Laparoscopic hiatal hernia repair	71 (20.2%)
Laparoscopic umbilical hernia repair	5 (1.4%)
Laparoscopic cholecystectomy	2 (0.6%)
Operative time (minutes), mean ± SD	94.1 ± 40.7

Categorical data are reported with frequency (n) and percentage (%). Continuous data are summarized as mean ± standard deviation or median (interquartile range). Values are rounded to the nearest tenth.
[a] Includes one conversion of RNYGB to SG (n=1)
[b] Includes Mini gastric bypass (n=4), SADI (one- or second-stage) (n=9), BPD-DS (one- or second-stage) (n=2), Conversion of SG to RYGB (n=9), Conversion of SADI to BPD-DS (n=1), and Re-do Gastro-jejunal anastomosis after RNYGB (n=2).
SD Standard Deviation, BMI body mass index (calculated as weight in kilograms divided by height in meters squared, ASA American Society of Anesthesiologists, PROMIS-29 Patient-Reported Outcomes Measurement Information System, IQR Interquartile Range, SG Sleeve Gastrectomy, RYGB Roux-en-Y Gastric Bypass, SADI Single-Anastomosis Duodenal-Ileal Bypass, DS Duodenal Switch, BPD-DS Biliopancreatic Diversion with Duodenal Switch

The most common laparoscopic bariatric procedures performed were SG (n=249, 71%) and RYGB (n=75, 21%) (Table 1). Concomitant surgical procedures included hernia repairs (hiatal [n=71, 20%], umbilical [n=5, 1%]) and cholecystectomy (n=2, 0.6%). Details about perioperative care and outcomes are described in Table 2. Many participants received pre-emptive analgesia (acetaminophen 59%, gabapentinoids 52%, opioids 50%) and a TAP block intraoperatively (55% [40 mL 0.25% Bupivacaine, bilateral]). During in-patient stay (POD 0 to POD 1), participants consumed a median of 92.5 morphine milligram equivalents (MME) of opioids (IQR 55-142.5). At discharge, analgesia prescriptions included opioids (100%) and acetaminophen (98%) as needed. A minority of participants received a prescription for NSAIDs (celecoxib around-the-clock [4%]). Of the opioids prescribed, oxycodone was the most common (57%), followed by hydromorphone (41%), tramacet (2%), codeine (0.3%), and morphine (0.3%). Mean length of stay was 1.6 ± 0.6 days (hospitals 1.1 ± 0.6, private clinic 2.0 ± 0.1) and 22 participants (6%) were discharged on the same day. Within 30 days of surgery, 20 participants (6%) experienced complications, 18 (5%) had an

emergency department visit, and 6 (0.3%) were re-admitted. Rates of specific complications are reported in Supplementary Table S2.

Table 2 Perioperative care and outcomes

Perioperative care characteristics	
Pre-emptive analgesia	
Acetaminophen	207 (59.0%)
Gabapentinoids [a]	184 (52.4%)
Opioids [b]	175 (49.9%)
Use of TAP Block [c]	193 (55.0%)
In-patient MMEs consumed (POD 0-1)	92.5 (55-142.5)
Analgesia prescription at discharge	
Opioids [d]	351 (100%)
Acetaminophen	343 (97.7%)
Celecoxib	13 (3.7%)
Number of opioid pills prescribed at discharge, median (IQR)	15 (15-16)
Postoperative outcomes	
7-day PROMIS-29 Pain Intensity, median (IQR)	2.5 (1-5)
7-day PROMIS-29 Pain Interference, median (IQR)	55.6 (52.0-61.2)
7-day Satisfaction with pain management	
Lower (≤ 8)	75 (24.3%)
High (≥ 9)	234 (75.7%)
Length of stay, mean (± SD)	1.6 ± 0.6
Same-day discharge	22 (6.3%)
30-day Complications	20 (5.7%)
30-day Emergency Department visits	18 (5.1%)
30-day Readmissions	6 (0.3%)

Categorical data are reported with frequency (n) and percentage (%). Continuous data are summarized as median (IQR) or mean (± SD). Values are rounded to the nearest hundredth.
[a] Includes Pregabalin (n=181) and Gabapentin (n=3)
[b] Includes Hydromorphone (n=166) and Oxycodone (n=9)
[c] TAP blocks were bilateral 40mL 0.25% bupivacaine with 1:200,000 Epinephrine.
[d] Includes Oxycodone (n=199), Hydromorphone (n=142), Tramacet (n=8) Morphine (n=1) and Codeine (n=1)
TAP: Transversus Abdominus Plane, POD: Postoperative Day, MME: Morphine Milligram Equivalent, PROMIS-29: Patient-Reported Outcomes Measurement Information System, IQR Interquartile Range, SD: Standard Deviation.

At 7 days after discharge, participants reported a median pain intensity of 2.5 (IQR 1 - 5) and pain interference level of 55.6 (IQR 52.0 - 61.2) (Table 2). In multivariate linear analysis, 7-day pain intensity was independently predicted by preoperative anxiety (β +0.04 [95% CI +0.01 to +0.07]) and pain expectation (+0.15 [95%CI +0.05 to +0.25]) (Table 3, full

model detailed in Supplementary Tables S3 and S4). Similarly, 7-day pain interference was predicted by preoperative anxiety (+0.22 [95% CI +0.11 to +0.33]), pain expectation (+0.47 [95%CI +0.10 to +0.84]) and younger age (-0.09 [95%CI -0.17 to -0.003]) (Table 3, full model detailed in Supplementary Tables S5 and S6).

At one week after discharge, most participants (76%) reported high satisfaction with their post-discharge pain management (score ≥ 9), while 24% reported a lower degree of satisfaction (≤ 8) (Table 2). In multivariate logistic regression, lower satisfaction was predicted by age (OR 0.97 [95%CI 0.948 to 0.998]), higher pain catastrophizing (OR 1.03 [95%CI 1.003 to 1.054]), low patient activation (OR 1.94 [95%CI 1.05 to 3.56]), and 30-day complications (OR 3.27 [95%CI 1.14 to 9.38]) (Table 3, full model detailed in Supplementary Tables S7 and S8). Following sensitivity analysis in which the threshold for lower satisfaction was changed to ≤ 7, low patient activation (OR 3.10 [95%CI 1.37 to 7.01]) and 30-day complications (OR 3.51 [95%CI 1.04 to 11.84]) remained significant predictors (Supplementary Table S9 and S10). When satisfaction was analyzed as a continuous variable, lower satisfaction was predicted by age (β -0.02 [95%CI -0.03 to -0.005]), higher pain catastrophizing (+0.02 [95%CI +0.01 to +0.04]), low patient activation (+0.61 [95%CI +0.24 to +0.98]), and 30-day complications (+0.97 [95%CI +0.29 to +1.66]) (Supplementary Table S11 and S12).

Table 3 7-Day post-discharge pain outcome prediction model after backward selection

Outcome	Predictors	Coefficient*	95% CI	p-value
7-Day Pain Intensity	BMI (higher)	0.025	[-0.005 to 0.055]	0.098
	Preoperative PROMIS-29 anxiety score (higher)	0.041	[0.012 to 0.070]	0.006
	Pain expectation (higher)	0.149	[0.047 to 0.250]	0.004
	Sleeve Gastrectomy (vs. anastomotic procedure)	-0.486	[-1.027 to 0.055]	0.078
7-Day Pain Interference	Age (older)	-0.089	[-0.174 to -0.003]	0.042
	Preoperative PROMIS-29 anxiety score (higher)	0.221	[0.109 to 0.333]	< 0.001
	Pain expectation (higher)	0.472	[0.098 to 0.845]	0.013
	Predictors	**Odds Ratio****	**95% CI**	**p-value**
7-Day Lower Satisfaction with Pain Management	Age (older)	0.973	[0.948 to 0.998]	0.037
	Race (non-White vs. White)	1.897	[0.982 to 3.665]	0.057
	Pain catastrophizing (higher)	1.028	[1.003 to 1.054]	0.031
	Patient activation (low vs. high)	1.943	[1.055 to 3.579]	0.033
	30-day complications (yes vs. no)	3.267	[1.138 to 9.383]	0.028

CI: Confidence Interval. BMI: Body Mass Index, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29.
* Coefficients should be interpreted as between-group differences in pain scores (dichotomous predictors) or increase in pain scores per unit increase (of continuous predictors) when all other variables held constant.
** Odds Ratios should be interpreted as difference in odds between groups (dichotomous predictors) or difference in odds per unit increase (of continuous predictors) when all other variables held constant.

2.4 Discussion

Pain management after bariatric surgery remains challenging given the increased risk for analgesia-related adverse events (e.g., opioid use disorder, marginal ulcers) and poor pain control [40, 41, 61, 65, 69, 71, 105-107]. Therefore, identifying modifiable factors associated with patient-reported pain outcomes may ultimately improve the quality of care for bariatric patients. In this cohort study involving a comprehensive multicenter database of patients undergoing laparoscopic bariatric surgery, we assessed potential predictors of 7-day postoperative pain intensity, pain interference with daily activities, and satisfaction with pain management. The analgesia strategies offered to study participants varied, but were generally multimodal including pre-emptive analgesia, TAP blocks, postoperative oral acetaminophen and opioids, with a minority of participants receiving NSAIDs. Under these pain management conditions, the median 7-day pain intensity reported by participants was 2.5 (deemed 'tolerable' pain) [76], pain interference with daily activities was 56 (deemed 'mild') [114], and most participants were highly satisfied with the pain management received (76% with satisfaction score $\geq$ 9). These findings are very different from those reported in existing literature where moderate-to-severe pain (NRS $\geq$ 4) was commonly experienced after bariatric surgery [40, 41]. Previous studies on this topic, however, focused on the early postoperative period (with 24 hours) and used different pain management standards (largely opioid-based, with intravenous patient-controlled administration) [40, 41]. In our cohort, postoperative pain outcomes were generally predicted by patients-related factors, including preoperative anxiety, pain expectation, pain catastrophizing (i.e., tendency to magnify the threat, ruminate about, and feel helpless in anticipation of, during, or following a painful event) [146], and patient activation (i.e., engagement in healthcare) [128]. These findings highlight that, although acute pain is certainly influenced by the physiological response to tissue trauma and pharmacological management [147], individuals' postoperative pain experiences are also determined by psychological and coping processes that should be targeted in quality improvement initiatives.

Our findings corroborate previous literature supporting that preoperative anxiety, pain catastrophizing, and pain expectation are relevant predictors of postoperative pain outcomes [148-150]. Although these factors can be measured distinctively, they share common traits (i.e., the tendency to catastrophize and expect the worst possible outcome are characteristics of anxiety disorders) [151] and can potentially be addressed using educational and

psycho-behavioral interventions. Preoperative education is an approach commonly used in clinical practice to set pain expectations and inform pain management strategies [152]. In the centers where the present study was conducted, all bariatric patients took part in a preoperative education session with a trained nurse, where postoperative pain is among the main topics of discussion. Our findings, however, suggest that these sessions may not address the needs of many patients (i.e., those with higher levels of anxiety, catastrophizing, and pain expectation) who are at increased risk for poor postoperative pain outcomes. Findings from a 2020 systematic review by Villa et al. [153] support that interventions, including relaxation techniques, mindfulness, or pain-specific coping strategies can improve postoperative pain experiences and be feasibly applied in the context of abdominal surgery. Potential limitations of these strategies are that they may involve substantial time and cost burden; therefore, this field may benefit from the development of approaches that are short, scalable, and widely accessible [150]. Recent research supports that targeted video-based interventions and mobile health apps have the potential to reduce patients' preoperative anxiety and improve pain outcomes [154, 155]. While our findings suggest that many bariatric patients may benefit from these interventions, more research is needed to guide the referral of patients to appropriate resources and services.

As with any patient-reported pain outcome, satisfaction with pain management is a highly subjective measure; however, satisfaction data provides valuable insight about quality of care as perceived by patients [156]. Notably, patient activation, as measured using a 13-item questionnaire assessing patients' knowledge, skill, and confidence for self-management [128] was a significant predictor of lower satisfaction with pain management. In other surgical contexts, patients with lower activation scores have been shown to have lower satisfaction and worse postoperative outcomes [127, 157, 158]. Strategies to improve patient activation in perioperative care may include educational interventions to empower patients to take an active role in pain management and use of health information technology to support active self-management and improve communication with providers [159, 160]. Further comparative-effectiveness research is required to determine the best paths to improve patient activation to ultimately improve postoperative pain outcomes. Other relevant predictors of postoperative pain outcomes identified in our study include younger age (associated with more pain interference and dissatisfaction) and 30-day complications (associated with more dissatisfaction). These findings corroborate previous

literature [115, 117, 161, 162] and highlight that initiatives to improve the quality of postoperative pain management should address the needs of these patient groups.

This cohort study has important strengths. We evaluated a prospective database containing comprehensive information about preoperative patient-reported health status, interventions, and postoperative outcomes. Our inclusion criteria were broad and participants were recruited from tertiary hospitals and a private surgical clinic, so our results reflect a range of bariatric surgery settings. Other strengths include a large sample size (n=351) sufficient to address our research aims, high follow-up rates (88%) with multiple imputations of missing data, and compliance with standardized guidelines to optimize reporting (STROBE) [109]. This study also has many limitations. Our analyses focused on secondary data from a cohort study focused on opioid prescribing and consumption after bariatric surgery. As with any post-hoc analysis, this study is not confirmatory and should be regarded as exploratory and hypotheses generating. Furthermore, we did not control our analyses for some care processes that may influence postoperative pain outcomes (i.e., adherence to multimodal pain management, content of preoperative pain education). Although our original database contained data regarding in-patient and post-discharge opioid consumption, assessing their relationship with pain outcomes in a cohort study invariably leads to a 'chicken-and-egg' dilemma (i.e., opioid use can improve [or worsen] pain outcomes, but also be an indicator of better [or worse] pain outcomes); therefore, we opted not to address opioid consumption in our analyses. Notably, the number of opioid pills prescribed at discharge did not impact pain outcomes. We opted to dichotomize the outcome 'satisfaction with pain management' given the skewed data distribution, which may increase interpretability but result in information loss [163]. To address this concern, sensitivity analyses were conducted (i.e., changing cut-offs and considering satisfaction as a continuous outcome) which produced similar results compared to our primary analysis. Our analyses were not adjusted by study site as this could potentially mask the association between pain outcomes with key variables that were unbalanced across sites (e.g., use of TAP blocks was more common at the academic centers). In our analyses, the use of TAP block did not impact postoperative pain outcomes (Supplementary Tables S3, S5, and S7) which corroborates findings from a recent meta-analysis focused on laparoscopic bariatric surgery [164]. The use of wound or peritoneal infiltration with local anesthetics may improve pain outcomes after bariatric surgery [165, 166] but these interventions were not consistently documented in medical records and not considered in our analyses. Liposomal bupivacaine and intravenous

acetaminophen were not part of patients' multimodal analgesia approach. Given the potential risk for the development of postoperative marginal ulcers [167, 168], the prescription of NSAIDs after bariatric surgery remains controversial; for this reason, NSAIDs were rarely prescribed to the patients included in our cohort. However, current ERAS guidelines for bariatric surgery endorse the use of multimodal analgesia including NSAIDs [50, 51] and emerging evidence supports the safety and effectiveness of this approach [169-171]. Also, the non-opioid drugs used in our study were generally prescribed for use 'as needed' while scheduled ('around-the-clock') use has been recommended to optimize pain control [171]. Therefore, we cannot exclude that the pain outcomes observed in our cohort could have been further improved with further optimization of multimodal analgesia.

2.5 Conclusion

In this multicenter cohort study, postoperative pain outcomes after laparoscopic bariatric surgery were generally predicted by patient-related factors, including preoperative anxiety, pain expectation, pain catastrophizing, and patient activation. These findings support the value of addressing educational, psychological, and coping strategies to improve postoperative pain outcomes after bariatric surgery. Further research is required to optimize preoperative pain education and guide the referral of patients to appropriate psycho-behavioral interventions.

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2.7 Disclosures

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CHAPTER 3: CONCLUSION AND FUTURE DIRECTION

Despite decades of improvement in postoperative pain management, uncontrolled pain continues to be an important factor associated with emergency department utilization, delayed recovery, and decreased quality of life after surgery [32, 104, 173]. Following bariatric surgery, surgeons often rely on analgesia using opioid drugs which carry important side effects (e.g., vomiting, constipation, respiratory depression) and long-term risks (e.g., persistent opioid use), further endangering patients [58, 60]. To improve perioperative care, the findings of this thesis support that patient-related factors are important predictors of pain outcomes after laparoscopic bariatric surgery. Notably, our study suggests that the number of opioid pills prescribed at discharge does not impact pain outcomes. Given these results, we highlight the importance of implementing interventions focused on preoperative anxiety, pain expectation, pain catastrophizing, and patient engagement to improve postoperative pain outcomes and potentially reduce the reliance on opioids for postoperative pain management after bariatric surgery.

Our findings corroborate previous literature supporting that anxious mental states and poor postoperative expectations are associated with worse postoperative pain outcomes [148-150, 174, 175]. These issues are particularly relevant to bariatric patients, among whom 12% have a concurrent diagnosis of anxiety disorder [176]. Findings from a recent ecological study by Baik & Newman suggest that anxious people ruminate and worry as a coping mechanism to avoid 'negative emotional contrasts'—that is, to emotionally prepare oneself in case something bad happens (e.g., excruciating postoperative pain) [177]. As underlined by the American Pain Society guideline on postoperative pain management, clinicians can potentially mitigate the deleterious effects of anxiety by addressing patients' uncertainty and misconceptions of postoperative pain at the time of preoperative education [178]. By setting reasonable pain expectations, patients can better prepare for surgery and make more informed decisions throughout their perioperative care [150]. Depending on the patient's needs, educational interventions can range from simple written or Web-based materials to individualized, multicomponent education sessions [178]. Improving preoperative education has additionally been shown to reduce postoperative opioid use and may potentially improve weight-loss outcomes, optimizing the efficacy of the bariatric procedure itself [152, 179, 180]. While other interventions such as relaxation techniques, mindfulness, and pain-specific

coping strategies have shown promise in improving postoperative pain outcomes, their widespread adoption may be hindered by significant time and cost requirements [153, 181].

The most effective interventions for addressing preoperative anxiety, pain expectation, pain catastrophizing, and patient engagement to optimize postoperative pain outcomes remain unclear [178]. To leverage the growing accessibility and affordability of mobile devices, future studies should explore the comparative effectiveness of video-based interventions and mobile health applications in enhancing postoperative pain outcomes. We believe research efforts in this area will contribute to the development of new guidelines with the potential to improve the quality of perioperative care for patients undergoing bariatric surgery.

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APPENDIX

Table S1. STROBE Statement Checklist

	Item No.	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	(a) 19
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	(b) 3
Introduction			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	20-21
Objectives	3	State specific objectives, including any prespecified hypotheses	20-21
Methods			
Study design	4	Present key elements of study design early in the paper	21
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	21
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	(a) 21-22
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	22-23
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	22

Bias	9	Describe any efforts to address potential sources of bias	24
Study size	10	Explain how the study size was arrived at	23-24
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	22-24
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	24
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	24-25
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	24-26
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarize follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	28

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	30
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	29
Discussion			
Key results	18	Summarize key results with reference to study objectives	28-29
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	33-34
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	34
Generalisability	21	Discuss the generalisability (external validity) of the study results	33
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	34

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org

Table S2. Rates And Definitions Of 30-Day Complications

Complication	Definition	Frequency
Intraoperative serosal burn	Serosal injury requiring primary repair and closure.	1 (0.3%)
Dehydration	Serum/plasma osmolality (pOsm) >300 or need for IV fluids.	1 (0.3%)
Incisional hernia	Palpable, reducible lump in the treated area, with or without symptoms.	1 (0.3%)
Anastomotic stricture	Narrowing of the gastric lumen associated with symptoms of upper gastrointestinal tract obstruction.	1 (0.3%)
Dysphagia	Not being able to swallow solids or/and liquids, requiring further endoscopic or surgical intervention.	1 (0.3%)
Myocardial infarction	Increase in cardiac biomarker values or characteristic ECG changes or imaging evidence of new loss of viable myocardium or new regional wall motion abnormality.	1 (0.3%)
Postoperative pain	Uncontrolled pain requiring emergency visit for assessment and pain management optimization.	1 (0.3%)
Surgical site infection	Visible pus and/or cellulitis without pus requiring debridement, drainage and/or antibiotics.	2 (0.6%)
Gastroesophageal reflux disease	New-onset reflux with need for treatment with acid-reducing medication.	2 (0.6%)
Urinary tract infection	Presence and growth of microbial pathogens in the urinary tract	2 (0.6%)
Diabetic Ketoacidosis	Hyperglycemia and metabolic acidosis with low serum bicarbonate level, high serum ketones level, or urinary ketones.	2 (0.6%)
Postoperative bleeding	Bleeding with need for revisional surgery and/or blood transfusions.	2 (0.6%)
Postoperative nausea/vomiting	Postoperative nausea and/or vomiting occurring in-hospital or post-discharge requiring an anti-emetic.	3 (0.8%)

Categorical data are reported with frequency (n) and percentage (%).

Table S3. Pre-Stepwise Regression Model Of 7-Day Post-Discharge Pain Intensity (Stata Output)

Multiple-imputation estimates			Imputations	=	**50**
Linear regression			Number of obs	=	**351**
			Average RVI	=	**0.1261**
			Largest FMI	=	**0.1601**
			Complete DF	=	**334**
DF Adjustment:	**Small sample**	DF:	min	=	**244.51**
			avg	=	**270.04**
			max	=	**318.99**
Model F test:	**Equal FMI**		F(16, 329.7)	=	**2.12**
Within VCE type	**OLS**		Prob > F	=	**0.0076**

Predictor	**Coefficient**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	-0.001	0.013	-0.03	[-0.027 to 0.026]	0.977
Sex (female vs. male)	0.013	0.312	0.04	[-0.602 to 0.628]	0.967
BMI (higher)	0.024	0.017	1.41	[-0.010 to 0.058]	0.158
ASA (≥ 3)	-0.218	0.284	-0.77	[-0.777 to 0.341]	0.443
Race (non-White vs. White)	0.289	0.334	0.87	[-0.368 to 0.946]	0.387
Preoperative PROMIS-29 anxiety score (higher)	0.024	0.020	1.21	[-0.015 to 0.064]	0.228
Preoperative PROMIS-29 depressive symptoms score (higher)	0.013	0.019	0.66	[-0.026 to 0.051]	0.510
Pain catastrophizing (higher)	0.012	0.014	0.81	[-0.017 to 0.040]	0.419
Patient activation (low vs. high)	0.282	0.289	0.98	[-0.287 to 0.851]	0.330
Chronic pain (yes vs. no)	0.083	0.277	0.30	[-0.463 to 0.628]	0.766
Pain expectation (higher)	0.145	0.054	2.69	[0.039 to 0.251]	0.007
Sleeve Gastrectomy (vs. anastomotic procedure)	-0.463	0.278	-1.66	[-1.011 to 0.086]	0.098
TAP Block (yes vs. no)	0.243	0.256	0.95	[-0.260 to 0.746]	0.343
Concomitant procedure (yes vs. no)	0.093	0.303	0.31	[-0.503 to 0.689]	0.759
Number of opioid pills prescribed (higher)	0.003	0.030	0.09	[-0.055 to 0.061]	0.925
30-day complications (yes vs. no)	0.731	0.550	1.33	[-0.351 to 1.813]	0.184
_constant	-0.998	1.674	-0.61	[-4.234 to 2.238]	0.544

The predictor with the largest p-value exceeding the alpha-to-remove value (0.1) is removed from the model and the regression is run anew. The model is finalized when no predictor p-value exceeds the alpha-to-remove value.
CI: Confidence Interval, BMI: Body Mass Index, ASA: American Society of Anesthesiologists, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29, LSG: Laparoscopic Sleeve Gastrectomy, TAP: Transversus Abdominus Plane, OLS: Ordinary Least Squares, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S4. Post-Stepwise Regression Model Of 7-Day Post-Discharge Pain Intensity (Primary Analysis; Stata Output)

Multiple-imputation estimates			Imputations	=	**50**
Linear regression			Number of obs	=	**351**
			Average RVI	=	**0.1138**
			Largest FMI	=	**0.1319**
			Complete DF	=	**346**
DF Adjustment:	**Small sample**		DF: min	=	**270.96**
			avg	=	**292.18**
			max	=	**309.90**
Model F test:	**Equal FMI**		F(4, 337.5)	=	**6.74**
Within VCE type	**OLS**		Prob > F	=	**< 0.0001**

Predictor	**Coefficient**	**Std. err.**	**t-value**	**95% CI**	**p-value**
BMI (higher)	0.025	0.015	1.66	[-0.005 to 0.055]	0.098
Preoperative PROMIS-29 anxiety score (higher)	0.041	0.015	2.76	[0.012 to 0.070]	0.006
Pain expectation (higher)	0.149	0.052	2.88	[0.047 to 0.250]	0.004
Sleeve Gastrectomy (vs. anastomotic procedure)	-0.486	0.275	-1.77	[-1.027 to 0.055]	0.078
_constant	-0.884	1.081	-0.82	[-3.011 to 1.243]	0.414

Coefficients should be interpreted as between-group differences in pain scores (dichotomous predictors) or increase in pain scores per unit increase (of continuous predictors), all other variables held constant.
CI: Confidence Interval, BMI: Body Mass Index, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29, SG: Sleeve Gastrectomy, OLS: Ordinary Least Squares, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S5. Pre-Stepwise Regression Model Of 7-Day Post-Discharge Pain Interference (Stata Output)

Multiple-imputation estimates		Imputations	=	**50**
Linear regression		Number of obs	=	**351**
		Average RVI	=	**0.1188**
		Largest FMI	=	**0.1556**
		Complete DF	=	**334**
DF Adjustment:	**Small sample**	DF: min	=	**247.36**
		avg	=	**273.72**
		max	=	**318.23**
Model F test:	**Equal FMI**	F(16, 329.9)	=	**2.95**
Within VCE type	**OLS**	Prob > F	=	**0.0001**

Predictor	**Coefficient**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	-0.072	0.049	-1.48	[-0.168 to 0.024]	0.139
Sex (female vs. male)	1.090	1.114	0.98	[-1.103 to 3.282]	0.329
BMI (higher)	0.033	0.064	0.52	[-0.092 to 0.158]	0.602
ASA (≥ 3)	-0.961	1.010	-0.95	[-2.949 to 1.026]	0.342
Race (non-White vs. White)	-0.156	1.210	-0.13	[-2.539 to 2.227]	0.897
Preoperative PROMIS-29 anxiety score (higher)	0.162	0.074	2.18	[0.016 to 0.309]	0.030
Preoperative PROMIS-29 depressive symptoms score (higher)	0.038	0.070	0.55	[-0.100 to 0.177]	0.584
Pain catastrophizing (higher)	0.062	0.052	1.20	[-0.040 to 0.164]	0.232
Patient activation (low vs. high)	1.449	1.050	1.38	[-0.618 to 3.516]	0.169
Chronic pain (yes vs. no)	0.750	0.996	0.75	[-1.210 to 2.711]	0.452
Pain expectation (higher)	0.421	0.198	2.13	[0.032 to 0.810]	0.034
Sleeve Gastrectomy (vs. anastomotic procedure)	-0.810	1.008	-0.80	[-2.794 to 1.173]	0.422
TAP Block (yes vs. no)	0.214	0.929	0.23	[-1.616 to 2.043]	0.818
Concomitant procedure (yes vs. no)	0.183	1.102	0.17	[-1.986 to 2.352]	0.868
Number of opioid pills prescribed (higher)	-0.050	0.108	-0.46	[-0.262 to 0.163]	0.647
30-day complications (yes vs. no)	2.054	2.040	1.01	[-1.962 to 6.071]	0.315
_constant	44.650	6.098	7.32	[32.639 to 56.660]	< 0.001

The predictor with the largest p-value exceeding the alpha-to-remove value (0.1) is removed from the model and the regression is run anew. The model is finalized when no predictor p-value exceeds the alpha-to-remove value.
CI: Confidence Interval, BMI: Body Mass Index, ASA: American Society of Anesthesiologists, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29, SG: Sleeve Gastrectomy, TAP: Transversus Abdominus Plane, OLS: Ordinary Least Squares, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S6. Post-Stepwise Regression Model Of 7-Day Post-Discharge Pain Interference (Primary Analysis; Stata Output)

Multiple-imputation estimates		Imputations	=	**50**
Linear regression		Number of obs	=	**351**
		Average RVI	=	**0.1257**
		Largest FMI	=	**0.1511**
		Complete DF	=	**347**
DF Adjustment:	**Small sample**	DF: min	=	**258.82**
		avg	=	**273.26**
		max	=	**287.43**
Model F test:	**Equal FMI**	F(3, 332.7)	=	**12.20**
Within VCE type	**OLS**	Prob > F	=	**< 0.0001**

Predictor	**Coefficient**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	-0.089	0.043	-2.04	[-0.174 to -0.003]	0.042
Preoperative PROMIS-29 anxiety score (higher)	0.221	0.057	3.88	[0.109 to 0.333]	< 0.001
Pain expectation (higher)	0.472	0.190	2.49	[0.098 to 0.845]	0.013
_constant	44.431	4.086	10.87	[36.386 to 52.477]	< 0.001

Coefficients should be interpreted as between-group differences in pain scores (dichotomous predictors) or increase in pain scores per unit increase (of continuous predictors), all other variables held constant.
CI: Confidence Interval, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29, OLS: Ordinary Least Squares, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S7. Pre-Stepwise Regression Model Of 7-Day Satisfaction With Pain Management (Stata Output)

Multiple-imputation estimates		Imputations	=	**50**	
Logistic regression		Number of obs	=	**351**	
		Average RVI	=	**0.1715**	
		Largest FMI	=	**0.3239**	
DF Adjustment:	**Large sample**	DF: min	=	**475.24**	
		avg	=	**3,161.53**	
		max	=	**11,896.76**	
Model F test:	**Equal FMI**	F(16, 35337.9)	=	**1.81**	
Within VCE type	**OIM**	Prob > F	=	**0.0241**	

Predictor	**Odds Ratio**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	0.996	0.015	-2.26	[0.937 to 0.995]	0.024
Sex (female vs. male)	0.805	0.289	-0.60	[0.398 to 1.628]	0.545
BMI (higher)	0.970	0.020	-1.43	[0.931 to 1.011]	0.152
ASA (≥ 3)	0.982	0.320	-0.05	[0.519 to 1.861]	0.956
Race (non-White vs. White)	1.999	0.697	1.99	[1.009 to 3.961]	0.047
Preoperative PROMIS-29 anxiety score (higher)	0.995	0.024	-0.23	[0.949 to 1.043]	0.819
Preoperative PROMIS-29 depressive symptoms score (higher)	1.009	0.024	0.40	[0.964 to 1.057]	0.690
Pain catastrophizing (higher)	1.037	0.016	2.38	[1.006 to 1.069]	0.018
Patient activation (low vs. high)	1.989	0.162	2.13	[1.057 to 3.744]	0.033
Chronic pain (yes vs. no)	0.834	0.261	-0.58	[0.451 to 1.540]	0.561
Pain expectation (higher)	0.945	0.059	-0.92	[0.836 to 1.067]	0.360
Sleeve Gastrectomy (vs. anastomotic procedure)	0.756	0.232	-0.91	[0.414 to 1.381]	0.362
TAP Block (yes vs. no)	0.972	0.289	-0.10	[0.542 to 1.743]	0.924
Concomitant procedure (yes vs. no)	1.153	0.396	0.42	[0.588 to 2.261]	0.678
Number of opioid pills prescribed (higher)	1.143	0.125	1.22	[0.922 to 1.416]	0.222
30-day complications (yes vs. no)	3.264	1.836	2.10	[1.083 to 9.833]	0.036
_constant	0.517	1.256	-0.27	[0.004 to 60.650]	0.786

The predictor with the largest p-value exceeding the alpha-to-remove value (0.1) is removed from the model and the regression is run anew. The model is finalized when no predictor p-value exceeds the alpha-to-remove value.
CI: Confidence Interval, BMI: Body Mass Index, ASA: American Society of Anesthesiologists, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29, SG: Sleeve Gastrectomy, TAP: Transversus Abdominus Plane, OIM: Observed Information Matrix, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S8. Post-Stepwise Regression Model Of 7-Day Satisfaction With Pain Management (Primary Analysis; Stata Output)

Multiple-imputation estimates		Imputations	=	**50**
Logistic regression		Number of obs	=	**351**
		Average RVI	=	**0.1555**
		Largest FMI	=	**0.1840**
DF Adjustment:	**Large sample**	DF: min	=	**1,465.28**
		avg	=	**3,046.09**
		max	=	**5,614.46**
Model F test:	**Equal FMI**	F(5, 12527.9)	=	**4.55**
Within VCE type	**OIM**	Prob > F	=	**0.0004**

Predictor	**Odds Ratio**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	0.973	0.013	-2.09	[0.948 to 0.998]	0.037
Race (non-White vs. White)	1.897	0.637	1.91	[0.982 to 3.665]	0.057
Pain catastrophizing (higher)	1.028	0.013	2.16	[1.003 to 1.054]	0.031
Patient activation (low vs. high)	1.943	0.605	2.13	[1.055 to 3.579]	0.033
30-day complications (yes vs. no)	3.267	1.758	2.20	[1.138 to 9.383]	0.028
_constant	0.982	0.628	-0.03	[0.281 to 3.438]	0.978

Odds Ratios should be interpreted as difference in odds between groups (dichotomous predictors) or difference in odds per unit increase (of continuous predictors), all other variables held constant.
CI: Confidence Interval, OIM: Observed Information Matrix, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S9. Sensitivity Analysis Of 7-Day Satisfaction With Pain Management (Pre-Stepwise; Reduced Threshold; Stata Output)

Multiple-imputation estimates		Imputations	=	**50**
Logistic regression		Number of obs	=	**351**
		Average RVI	=	**0.1394**
		Largest FMI	=	**0.2503**
DF Adjustment:	**Large sample**	DF: min	=	**794.07**
		avg	=	**4,929.53**
		max	=	**18,043.06**
Model F test:	**Equal FMI**	F(16, 50037.0)	=	**1.16**
Within VCE type	**OIM**	Prob > F	=	**0.2927**

Predictor	**Odds Ratio**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	0.962	0.022	-1.68	[0.920 to 1.006]	0.093
Sex (female vs. male)	1.165	0.652	0.27	[0.389 to 3.491]	0.785
BMI (higher)	0.968	0.030	-1.04	[0.912 to 1.029]	0.299
ASA (≥ 3)	1.409	0.684	0.71	[0.544 to 3.652]	0.480
Race (non-White vs. White)	1.003	0.558	0.01	[0.337 to 2.987]	0.996
Preoperative PROMIS-29 anxiety score (higher)	1.028	0.037	0.77	[0.958 to 1.103]	0.441
Preoperative PROMIS-29 depressive symptoms score (higher)	0.960	0.033	-1.20	[0.897 to 1.027]	0.231
Pain catastrophizing (higher)	1.040	0.023	1.77	[0.996 to 1.087]	0.077
Patient activation (low vs. high)	3.015	1.347	2.47	[1.255 to 7.240]	0.014
Chronic pain (yes vs. no)	0.716	0.342	-0.70	[0.281 to 1.826]	0.484
Pain expectation (higher)	0.910	0.080	-1.07	[0.766 to 1.082]	0.285
Sleeve Gastrectomy (vs. anastomotic procedure)	0.889	0.410	-0.26	[0.360 to 2.194]	0.798
TAP Block (yes vs. no)	1.142	0.507	0.30	[0.478 to 2.728]	0.766
Concomitant procedure (yes vs. no)	1.355	0.667	0.62	[0.516 to 3.555]	0.537
Number of opioid pills prescribed (higher)	0.974	0.177	-0.14	[0.683 to 1.391]	0.886
30-day complications (yes vs. no)	3.538	2.427	1.84	[0.922 to 13.573]	0.065
_constant	2.685	10.201	0.26	[0.002 to 4613.784]	0.795

The predictor with the largest p-value exceeding the alpha-to-remove value (0.1) is removed from the model and the regression is run anew. The model is finalized when no predictor p-value exceeds the alpha-to-remove value.
CI: Confidence Interval, BMI: Body Mass Index, ASA: American Society of Anesthesiologists, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29, SG: Sleeve Gastrectomy, TAP: Transversus Abdominus Plane, OIM: Observed Information Matrix, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S10. Sensitivity Analysis Of 7-Day Satisfaction With Pain Management (Post-Stepwise; Reduced Threshold; Stata Output)

Multiple-imputation estimates			Imputations	=	**50**
Logistic regression			Number of obs	=	**351**
			Average RVI	=	**0.1169**
			Largest FMI	=	**0.1362**
DF Adjustment:	**Large sample**		DF: min	=	**2,668.63**
			avg	=	**6,621.29**
			max	=	**13,025.66**
Model F test:	**Equal FMI**		F(2, 8314.2)	=	**5.21**
Within VCE type	**OIM**		Prob > F	=	**0.0055**

Predictor	**Odds Ratio**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Patient activation (low vs. high)	3.099	1.291	2.72	[1.369 to 7.013]	0.007
30-day complications (yes vs. no)	3.513	2.178	2.03	[1.042 to 11.842]	0.043
_constant	0.058	0.017	-9.73	[0.033 to 1.03]	< 0.001

Odds Ratios should be interpreted as difference in odds between groups (dichotomous predictors) or difference in odds per unit increase (of continuous predictors), all other variables held constant.
CI: Confidence Interval, OIM: Observed Information Matrix, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S11. Sensitivity Analysis Of 7-Day Satisfaction With Pain Management (Pre-Stepwise; Linear Regression; Stata Output)

Multiple-imputation estimates			Imputations	=	**50**
Linear regression			Number of obs	=	**351**
			Average RVI	=	**0.1527**
			Largest FMI	=	**0.2405**
			Complete DF	=	**334**
DF Adjustment:	**Small sample**	DF:	min	=	**196.12**
			avg	=	**258.06**
			max	=	**305.30**
Model F test:	**Equal FMI**		F(16, 328.8)	=	**2.87**
Within VCE type	**OLS**		Prob > F	=	**0.0002**

Predictor	**Coefficient**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	-0.020	0.009	-2.34	[-0.037 to -0.003]	0.020
Sex (female vs. male)	-0.140	0.195	-0.72	[-0.525 to 0.245]	0.474
BMI (higher)	-0.010	0.011	-0.93	[-0.032 to 0.011]	0.351
ASA (≥ 3)	0.010	0.180	0.06	[-0.344 to 0.364]	0.955
Race (non-White vs. White)	0.280	0.220	1.27	[-0.154 to 0.715]	0.205
Preoperative PROMIS-29 anxiety score (higher)	0.006	0.013	0.45	[-0.020 to 0.032]	0.654
Preoperative PROMIS-29 depressive symptoms score (higher)	-0.004	0.013	-0.31	[-0.030 to 0.022]	0.758
Pain catastrophizing (higher)	0.027	0.009	2.92	[0.009 to 0.046]	0.004
Patient activation (low vs. high)	0.604	0.189	3.19	[-0.231 to 0.977]	0.002
Chronic pain (yes vs. no)	-0.186	0.175	-1.06	[-0.531 to 0.159]	0.290
Pain expectation (higher)	-0.017	0.035	-0.49	[-0.087 to 0.052]	0.626
Sleeve Gastrectomy (vs. anastomotic procedure)	-0.118	0.177	-0.67	[-0.467 to 0.231]	0.505
TAP Block (yes vs. no)	0.043	0.163	0.26	[-0.279 to 0.364]	0.794
Concomitant procedure (yes vs. no)	-0.011	0.191	-0.06	[-0.388 to 0.365]	0.952
Number of opioid pills prescribed (higher)	0.029	0.019	1.53	[-0.008 to 0.067]	0.128
30-day complications (yes vs. no)	0.965	0.358	2.70	[0.260 to 1.671]	0.008
_constant	1.400	1.062	1.32	[-0.693 to 3.492]	0.189

The predictor with the largest p-value exceeding the alpha-to-remove value (0.1) is removed from the model and the regression is run anew. The model is finalized when no predictor p-value exceeds the alpha-to-remove value.
CI: Confidence Interval, BMI: Body Mass Index, ASA: American Society of Anesthesiologists, PROMIS-29: Patient-Reported Outcomes Measurement Information System 29, SG: Sleeve Gastrectomy, TAP: Transversus Abdominus Plane, OLS: Ordinary Least Squares, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates

Table S12. Sensitivity Analysis Of 7-Day Satisfaction With Pain Management (Post-Stepwise Linear Regression; Stata Output)

Multiple-imputation estimates			Imputations	=	**50**
Linear regression			Number of obs	=	**351**
			Average RVI	=	**0.1625**
			Largest FMI	=	**0.1724**
			Complete DF	=	**346**
DF Adjustment:	**Small sample**		DF: min	=	**244.09**
			avg	=	**266.81**
			max	=	**293.43**
Model F test:	**Equal FMI**		F(4, 329.8)	=	**9.49**
Within VCE type	**OLS**		Prob > F	=	**< 0.0001**

Predictor	**Coefficient**	**Std. err.**	**t-value**	**95% CI**	**p-value**
Age (older)	-0.019	0.007	-2.66	[-0.034 to -0.005]	0.008
Pain catastrophizing (higher)	0.024	0.008	3.07	[0.009 to 0.040]	0.002
Patient activation (low vs. high)	0.612	0.187	3.28	[0.244 to 0.979]	0.001
30-day complications (yes vs. no)	0.974	0.348	2.79	[0.288 to 1.660]	0.006
_constant	1.240	0.347	3.57	[0.556 to 1.923]	< 0.001

Coefficients should be interpreted as between-group differences in pain scores (dichotomous predictors) or increase in pain scores per unit increase (of continuous predictors), all other variables held constant.
CI: Confidence Interval, TAP: Transversus Abdominus Plane, OLS: Ordinary Least Squares, FMI: Fraction of Missing Information, DF: Degrees of Freedom, RVI: Relative Variance Inflation, VCE: Variance-Covariance Matrix of the Estimates