

Postoperative pain burden and recovery comfort after ambulatory strabismus surgery under general anesthesia: a single-center retrospective cohort study

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Abstract

Background

Ambulatory strabismus surgery is often regarded as a low-pain ophthalmic procedure, but postoperative symptoms after discharge may still affect recovery quality. Pain intensity alone may not fully capture early recovery because comfort is also influenced by nausea, dizziness, ocular irritation, and home-based activity after discharge. This study described postoperative pain and comfort trajectories after ambulatory strabismus surgery under general anesthesia and explored factors associated with cumulative pain burden.

Methods

This single-center retrospective cohort study included 202 adults who underwent elective ambulatory strabismus correction under general anesthesia at Zhongshan Ophthalmic Center between July and September 2019. Numeric rating scale (NRS) pain scores and comfort scores were recorded at 0.5, 2, 6, 10, and 24 h postoperatively. Cumulative pain burden was calculated as the area under the NRS score-time curve from 0.5 to 24 h. Generalized estimating equations were used to analyze repeated pain and comfort scores, and multivariable linear regression with HC3 robust standard errors was used to explore factors associated with pain burden.

Results

Pain scores were low overall but showed a time-dependent pattern. Mean NRS pain score decreased from 1.35 (SD 1.27) at 0.5 h to 0.58 (SD 1.16) at 10 h, then increased to 1.06 (SD 1.10) at 24 h. Comfort scores were also low, but the proportion of patients reporting no discomfort decreased from 89.1% at 10 h to 76.7% at 24 h. Median cumulative pain burden was 15.38 NRS.h (IQR 7.00–29.00). Higher preoperative NRS pain score and higher preoperative anxiety category were independently associated with greater pain burden. The association between pain and comfort varied over time and was strongest during the 6–10 h recovery period, while postoperative complications remained strongly associated with discomfort.

Conclusions

Adults undergoing ambulatory strabismus surgery under general anesthesia experienced low average pain intensity, but pain and discomfort increased again by 24 h after discharge. Preoperative anxiety and baseline pain may help identify patients who need closer postoperative analgesic guidance. These findings support routine post-discharge assessment of pain, comfort, and complications during the first postoperative day.

Trial registration:

Not applicable.

Introduction

Postoperative pain should not be interpreted only from a single early score. Studies using repeated postoperative assessments have identified distinct acute pain trajectories, showing that pain intensity can follow clinically meaningful time courses rather than isolated values ^[1, 2]. Evidence from same-day surgery also shows that postoperative pain can remain clinically relevant beyond the immediate recovery unit ^[3]. Rebound pain after peripheral nerve block has been studied specifically in ambulatory surgery ^[4], and regional anesthesia remains an important analgesic strategy in ambulatory surgical care ^[5].

Postoperative recovery after ambulatory surgery is also broader than pain intensity alone. In an ambulatory spine surgery trial, recovery assessment included opioid use, pain, quality of recovery, recovery time, and postoperative nausea and vomiting ^[6]. In adult strabismus surgery, postoperative nausea and vomiting has also been studied as a procedure-relevant recovery problem [9]. These observations support assessing comfort and postoperative symptoms alongside pain intensity after discharge.

Adult strabismus surgery is commonly performed as day-case ophthalmic surgery under general anesthesia in specialized centers. A survey of postoperative adult strabismus analgesia found that most surgeons prescribed acetaminophen and/or non-steroidal anti-inflammatory drugs, with opioids used less often ^[7]. A randomized study of topical proparacaine addressed postoperative comfort after strabismus surgery ^[8], and another adult strabismus trial focused on postoperative nausea and vomiting ^[9]. However, these studies address analgesic practice, a topical comfort intervention, or PONV prevention rather than repeated pain and comfort trajectories across the first 24 h after ambulatory surgery.

A repeated-measures approach may identify clinically useful recovery patterns that are missed by single time-point pain scores ^[1, 2]. Cumulative pain burden, summarized as the area under the NRS score-time curve, can also represent total pain exposure across the early recovery period. We therefore studied adults who underwent ambulatory strabismus correction under general anesthesia in a day-surgery setting. The objectives were to describe pain and comfort trajectories from 0.5 to 24 h postoperatively and to explore patient- and procedure-related factors associated with cumulative pain burden.

Methods

Study design and setting

This was a single-center retrospective observational cohort study using the ambulatory surgery medical record database of Zhongshan Ophthalmic Center, Sun Yat-sen University. Data were extracted from the clinical archives of adult patients who underwent consecutive elective ambulatory strabismus correction surgery between July 2019 and September 2019. The study involved no prospective intervention or randomization and is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement ^[10].

The study protocol was approved by the Institutional Review Board of Zhongshan Ophthalmic Center, Sun Yat-sen University (Ethics Approval No. 2019KYPJ056), and was conducted in accordance with the Declaration of Helsinki. Given the retrospective analysis of anonymized medical records, the Ethics Committee waived the requirement for individual informed consent. The analytic cohort flow is shown in Supplementary Fig. S1.

Participants

Patients were eligible if they were aged 18 years or older, underwent elective ambulatory strabismus surgery under general anesthesia during the study period, and had complete pain and comfort assessments at all five predefined postoperative time points: 0.5, 2, 6, 10, and 24 h. Patients were excluded if pain or comfort assessments were missing at any time point, if psychiatric disorders or cognitive or communication impairment could affect pain assessment, or if core clinical records were incomplete. The cleaned analytic dataset contained 202 eligible patients.

Anesthesia and surgical management

The anesthesia and surgical protocols described here reflect routine clinical care recorded in the medical record and were not study-designed interventions. All procedures were performed under general anesthesia without preoperative medication. Standard monitoring included electrocardiography, heart rate, non-invasive blood pressure, pulse oxygen saturation, and end-tidal carbon dioxide. Anesthesia was induced with propofol 1.5–2.5 mg/kg and fentanyl 1–2 micrograms/kg, followed by laryngeal mask airway insertion. Anesthesia was maintained with continuous infusions of propofol 6 mg/kg/h and remifentanyl 0.15–0.20 micrograms/kg/min. Intraoperative analgesia consisted of flurbiprofen axetil or nalbuphine, and prophylactic antiemetic therapy included a 5-HT₃ receptor antagonist combined with dexamethasone. All procedures were performed by attending or associate chief physicians experienced in strabismus surgery.

Data collection

Variables were extracted from medical records and grouped into demographic and clinical characteristics, perioperative variables, pharmacological variables, and preoperative baseline assessments. Demographic and clinical variables included age, sex, body mass index, marital status, smoking and alcohol history, education level, prior ocular surgery, American Society of Anesthesiologists physical status, and prior use of analgesic or sedative medication. Perioperative variables included duration of anesthesia, duration of surgery, waiting time before surgery, number of extraocular muscles corrected, and surgeon seniority. Pharmacological variables included preoperative analgesic or sedative use within 1 h before surgery, intraoperative analgesic type, and intraoperative antiemetic use. Preoperative anxiety was assessed with the Self-Rating Anxiety Scale on the day before surgery [11], and preoperative pain was assessed with an 11-point NRS [12, 13].

Outcomes

The primary outcome was postoperative pain trajectory, defined by NRS pain scores from 0 to 10 at 0.5, 2, 6, 10, and 24 h postoperatively. Secondary outcomes were postoperative comfort scores at the same time points, cumulative pain burden from 0.5 to 24 h, postoperative complications including nausea, vomiting, dizziness, and headache, and the longitudinal association between pain intensity and comfort score. Comfort was scored from 0 to 10, with 0 indicating the most comfortable state and 10 indicating the least comfortable state.

Pain burden calculation

Cumulative pain burden was calculated with the linear trapezoidal method using the five NRS pain scores and was expressed in NRS.h. Because the first recorded postoperative score was at 0.5 h, the AUC represents the 0.5–24 h interval rather than a true 0–24 h interval. A time-normalized AUC, calculated as total AUC divided by 23.5 h, was used for robustness testing in multivariable models.

Statistical analysis

Continuous variables were assessed for normality with the Shapiro-Wilk test. Normally distributed variables are presented as mean and standard deviation, and non-normally distributed variables are presented as median and interquartile range. Categorical variables are presented as frequency and percentage. Repeated pain scores were analyzed with generalized estimating equations using a Gaussian distribution, identity link, and exchangeable working correlation structure^[14]. Time was treated as a categorical variable, with 0.5 h as the reference, and pairwise comparisons were adjusted with the Holm method.

Univariable and multivariable linear regression analyses were performed to explore factors associated with 0.5–24 h pain AUC. Variables with $P < 0.10$ in univariable analysis were entered simultaneously into the multivariable model. HC3 heteroscedasticity-consistent standard errors were used because residuals were non-normally distributed^[15]. The longitudinal association between pain and comfort was analyzed with a GEE model in which comfort score was the dependent variable and time-varying pain score, time, pain-by-time interaction terms, and time-varying complication status were fixed effects. Missing waiting-time data were handled by available-case analysis, and no imputation was performed. Sensitivity analyses treated NRS scores as ordinal or binary outcomes. Statistical significance was set at two-sided $P < 0.05$.

Results

Baseline characteristics and missing data

A total of 202 adult patients were included. Pain and comfort scores were complete at all five postoperative time points. Waiting time before surgery was missing in one patient and was analyzed by available-case analysis. Baseline demographic and clinical characteristics are summarized in Table 1. The cohort had a median age of 27.0 years (IQR 22.0–33.8), with a balanced sex distribution (100 men [49.5%] and 102 women [50.5%]). Most patients were ASA physical status I (164/202, 81.2%). Perioperative characteristics and preoperative baseline assessments are shown in Table 2. Baseline pain and anxiety were low, with median preoperative NRS pain score 0 (IQR 0–0) and median SAS-derived anxiety category 1 (IQR 1–1).

Postoperative pain and comfort trajectories

Postoperative pain intensity was low overall but changed over time (Fig. 1). Mean NRS pain score was highest at 0.5 h (1.35 [SD 1.27]), decreased to 0.58 (SD 1.16) at 10 h, and increased to 1.06 (SD 1.10) at 24 h. The corresponding median scores were 1.0 (IQR 0–2), 0 (IQR 0–0), and 1.0 (IQR 0–2), respectively. Comfort scores were also low, with a median of 0 at all time points; however, the proportion of patients reporting no discomfort decreased from 89.1% at 10 h to 76.7% at 24 h. These results indicate a statistically detectable but clinically modest increase in symptoms by 24 h after discharge.

Sensitivity analyses supported the time-dependent pain pattern (Supplementary Table S1). The ordinal GEE model showed a significant overall time effect (Wald chi-square = 42.13, df = 4, $P < 0.001$), as did the logistic GEE models for any pain (Wald chi-square = 99.30, df = 4, $P < 0.001$) and NRS ≥ 2 (Wald chi-square = 35.25, df = 4, $P < 0.001$). The increase from 10 h to 24 h was retained across these sensitivity models.

Pain burden and associated factors

The 0.5-24 h pain AUC had a right-skewed distribution, with a median of 15.38 NRS.h (IQR 7.00-29.00), mean of 20.52 (SD 19.79), and range from 0 to 132.50. Twenty-three patients (11.4%) had an AUC of zero. The median time-normalized AUC was 0.65 NRS units (IQR 0.30-1.23). Factors associated with cumulative pain burden are reported in Table 3 and illustrated in Fig. 2.

In the multivariable model with HC3 robust standard errors, higher preoperative NRS pain score and higher SAS-derived anxiety category were associated with greater cumulative postoperative pain burden. Prior analgesic use was associated with pain burden in univariable analysis but was attenuated after adjustment and should be interpreted as exploratory. In an additional sensitivity model including age and sex, the estimates for preoperative pain and anxiety remained similar, whereas age and sex were not associated with AUC.

Pain-comfort association

In the complication-adjusted longitudinal model, time-varying postoperative complications were associated with higher discomfort scores (Table 4). The association between pain and comfort varied by postoperative time: the estimated pain-comfort slope was greater at 6 h and 10 h than at 0.5 h, whereas the 24 h interaction was not statistically different from the reference. These data support a stronger mid-recovery pain-comfort relationship rather than a uniform association across the entire 24 h recovery period (Fig. 3).

In the binary sensitivity model for any discomfort, postoperative complications remained strongly associated with discomfort (Supplementary Table S1). Pain-by-time interactions remained evident at 6 h and 10 h but not at 24 h, whereas the main pain effect was not significant after dichotomizing comfort. These findings suggest that comfort should be interpreted as a broader recovery construct rather than a direct binary proxy for pain intensity.

Discussion

In this single-center retrospective cohort of 202 adults undergoing ambulatory strabismus surgery under general anesthesia, postoperative pain was low on average but followed a clinically relevant time-dependent pattern. Pain scores decreased from early recovery to 10 h and then increased again at 24 h. Preoperative anxiety and baseline pain intensity were associated with greater cumulative pain burden, and the relationship between pain and comfort was strongest during the 6–10 h recovery period.

The late increase in pain is plausible in an ambulatory anesthesia setting. Patients are discharged before the full first postoperative day has elapsed, and symptoms may become more apparent as analgesic effects decline, activity resumes at home, or ocular irritation develops. Studies using group-based trajectory analysis after liver cancer surgery and video-assisted thoracoscopic surgery have identified postoperative pain trajectory groups, including rebound or late-increasing patterns^[16, 17]. A bariatric surgery cohort also examined postoperative pain trajectories and opioid requirements after laparoscopic surgery^[18]. Although the pain intensity observed in our cohort was milder than in these more invasive procedures, the 24 h increase is relevant for discharge counseling because it occurred after direct in-hospital observation had ended.

The sensitivity analyses support the robustness of the pain trajectory finding. The overall time effect and the 10-to-24 h increase were retained when NRS pain was modeled as an ordered outcome and when pain was dichotomized using simple clinical thresholds. In contrast, the pain-comfort association was less stable after

comfort was dichotomized. This distinction is important because comfort reflects a broader patient-reported recovery state that may include nausea, dizziness, headache, ocular irritation, and anxiety, rather than pain alone.

Adult strabismus surgery is often managed with non-opioid analgesia, and the low average pain scores in this cohort are consistent with that practice. However, low mean pain does not exclude meaningful between-patient variability or delayed symptoms. A systematic review of non-pharmacological interventions in breast cancer surgery identified preoperative anxiety and acute postoperative pain as clinically relevant perioperative outcomes ^[19]. A separate systematic review and meta-analysis specifically examined the association between preoperative anxiety and chronic postsurgical pain after general anesthesia ^[20]. Our findings do not establish causality, but they suggest that brief preoperative screening may help identify patients who could benefit from more specific analgesic instructions or follow-up.

Surgical variables, including the number of muscles operated, were not independently associated with pain burden after adjustment. This finding should be interpreted cautiously because the cohort came from a specialized center and the range of procedural complexity was limited. It may nevertheless indicate that, for routine adult ambulatory strabismus surgery, patient-level vulnerability factors may be more informative than procedural variables for anticipating early postoperative pain burden.

The findings also support parallel assessment of pain, comfort, and complications after discharge. Postoperative nausea and vomiting remain common postoperative problems after general anesthesia, and consensus guidance emphasizes risk-based prevention ^[21]. Evidence syntheses of antiemetic drugs further support prophylaxis as an important component of postoperative care ^[22]. Adult strabismus surgery also carries postoperative nausea and vomiting risk ^[9]. An oculoplastic day-surgery trial evaluated multimodal analgesia using pain and quality-of-recovery outcomes ^[23], while a longitudinal day-surgery study assessed patient experiences and recovery quality after discharge ^[24]. For anesthesia teams and ambulatory surgery units, this argues for discharge instructions that cover the full first postoperative day, including expected timing of pain changes, non-opioid analgesic use, warning symptoms, and management of nausea or dizziness.

This study has limitations. First, the retrospective design cannot exclude residual confounding, selection bias, or measurement variability in routine clinical records. Second, the single-center setting may limit generalizability to other institutions, anesthesia protocols, and patient populations. Third, comfort was measured with a simple NRS-based score rather than a validated multidomain recovery instrument. Fourth, data on rescue analgesic use after patients returned home were limited. Finally, the study was exploratory and was not designed to test whether anxiety screening or targeted follow-up improves postoperative outcomes. Prospective studies should evaluate structured analgesic guidance and post-discharge follow-up strategies for patients at higher risk of pain burden.

In conclusion, adults undergoing ambulatory strabismus surgery under general anesthesia experienced low average postoperative pain, but pain and discomfort increased again by 24 h after discharge. Preoperative anxiety and baseline pain were associated with greater cumulative pain burden. Routine assessment of pain, comfort, and postoperative complications across the first postoperative day may improve patient counseling and recovery management after ambulatory strabismus surgery.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board of Zhongshan Ophthalmic Center, Sun Yat-sen University (Ethics Approval No. 2019KYPJ056). The study was conducted in accordance with the Declaration of Helsinki. The Ethics Committee waived the requirement for individual informed consent because this was a retrospective analysis of anonymized medical records.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Y.W. and Z.Z. contributed equally to this work. Y.W. and Z.Z. contributed to data collection, statistical analysis, and manuscript drafting. J.H., H.M., and Y.M. contributed to data acquisition and manuscript revision. L.X. and Z.Y. conceived and supervised the study. All authors reviewed and approved the final manuscript.

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Tables

Table 1. Baseline demographic and clinical characteristics

Data are presented as median (interquartile range) or n (%), unless otherwise indicated. Abbreviations: ASA, American Society of Anesthesiologists physical status classification; IQR, interquartile range.

Characteristics	n	Value
Age (years)	202	27.00 (22.00–33.75)
Sex	202	
Male		100 (49.5%)
Female		102 (50.5%)
Body mass index (kg/m ²)	202	21.23 (19.42–23.48)
ASA physical status	202	
I		164 (81.19%)
II		36 (17.82%)
III		2 (0.99%)
Married, n (%)	202	67 (33.2%)
Smoking, n (%)	202	34 (16.8%)
Alcohol consumption, n (%)	202	31 (15.3%)
Education level, n (%)	202	
Middle school or primary school		49 (24.3%)
High school		98 (48.5%)
College or above		55 (27.2%)
History of surgery on ipsilateral eye, n (%)	202	33 (16.3%)
History of surgery on contralateral eye, n (%)	202	16 (7.9%)
Prior analgesic use, n (%)	202	43 (21.3%)
Prior sedative use, n (%)	202	10 (5.0%)
Analgesics within 1 h preoperatively, n (%)	202	3 (1.5%)
Sedatives within 1 h preoperatively, n (%)	202	3 (1.5%)

Table 2. Perioperative characteristics and preoperative baseline assessments

Preoperative anxiety category was derived from the Self-Rating Anxiety Scale (SAS): category 1 = SAS score < 50; category 2 = SAS score ≥ 50. Waiting time was the interval from admission to the operating room to induction of anesthesia. Data are presented as median (interquartile range) or n (%). Abbreviations: IQR, interquartile range; NRS, numeric rating scale; SAS, Self-Rating Anxiety Scale.

Characteristics	n	Value
Preoperative NRS pain score	202	0.00 (0.00–0.00)
Preoperative anxiety category (SAS)¶	202	1.00 (1.00–1.00)
Duration of anaesthesia (min)	202	48.50 (40.25–60.00)
Duration of surgery (min)	202	25.00 (19.00–31.75)
Waiting time before surgery (min)¶	202	90.00 (55.00–136.00)
Number of muscles operated¶	202	2.00 (2.00–2.00)
Surgeon seniority, n (%)	202	
Senior (≥ 300 cases)		100 (49.5%)
Junior (< 300 cases)		102 (50.5%)

Table 3. Factors associated with postoperative pain burden from 0.5 to 24 h

The outcome was cumulative pain burden quantified as area under the NRS score-time curve from 0.5 to 24 h (NRS.h). Variables with $P < 0.10$ in univariable analysis were entered simultaneously into the multivariable model. Multivariable estimates use HC3 heteroscedasticity-robust standard errors. Abbreviations: AUC, area under the curve; CI, confidence interval; HC3, heteroscedasticity-consistent standard errors; NRS, numeric rating scale; SAS, Self-Rating Anxiety Scale.

Characteristics	Univariable Analysis	Univariable Analysis	Univariable Analysis	Multivariable Analysis	Multivariable Analysis	Multivariable Analysis
	β	95% CI	P	β	95% CI	P
Body mass index (kg/m ²)	0.052	-0.67, 0.77	0.888	—	—	—
Preoperative NRS pain score	11.881	1.83, 21.93	0.021	10.291	0.44, 20.14	0.041*
Preoperative anxiety (SAS)¶	21.867	4.42, 39.32	0.014	18.142	0.77, 35.51	0.041*
Duration of anaesthesia (min)	0.001	-0.18, 0.18	0.994	—	—	—
Duration of surgery (min)	0.054	-0.18, 0.29	0.647	—	—	—
Waiting time before surgery (min)	-0.014	-0.07, 0.04	0.610	—	—	—
Number of muscles operated	3.457	-0.05, 6.96	0.053	2.444	-1.02, 5.90	0.165
Surgeon seniority	3.788	-1.69, 9.27	0.174	—	—	—
Analgesics within 1 h pre-op	-6.707	-29.44, 16.03	0.561	—	—	—
Sedatives within 1 h pre-op	-1.716	-24.47, 21.03	0.882	—	—	—
Prior analgesic use, n (%)	8.268	1.64, 14.89	0.015	7.876	1.39, 14.36	0.061
Prior sedative use, n (%)	9.367	-2.58, 21.31	0.124	—	—	—

Table 4. Longitudinal association between NRS pain score and comfort score

The dependent variable was comfort score (0 = most comfortable; 10 = least comfortable). Time was treated as categorical, with 0.5 h as the reference. Comp_t indicates any postoperative complication at or before each time point. Abbreviations: CI, confidence interval; Comp_t, time-varying complication status; GEE, generalized estimating equations; NRS, numeric rating scale.

Parameter	β	95% CI	P
Intercept (reference: 0.5 h)	0.057	-0.097 to 0.211	0.466
NRS (main effect)	0.111	0.014 to 0.208	0.025
Time: 2 h	-0.129	-0.253 to 0.006	0.040
Time: 6 h	-0.138	-0.275 to 0.001	0.049
Time: 10 h	-0.235	-0.367 to -0.103	<0.001
Time: 24 h	-0.069	-0.263 to 0.124	0.482
NRS $\times$ Time: 2 h	0.075	-0.035 to 0.184	0.182
NRS $\times$ Time: 6 h	0.145	0.015 to 0.275	0.029
NRS $\times$ Time: 10 h	0.140	0.011 to 0.268	0.033
NRS $\times$ Time: 24 h	0.014	-0.156 to 0.185	0.869
Time-varying complication status (Comp_t)	0.937	0.685 to 1.190	<0.001

Figures

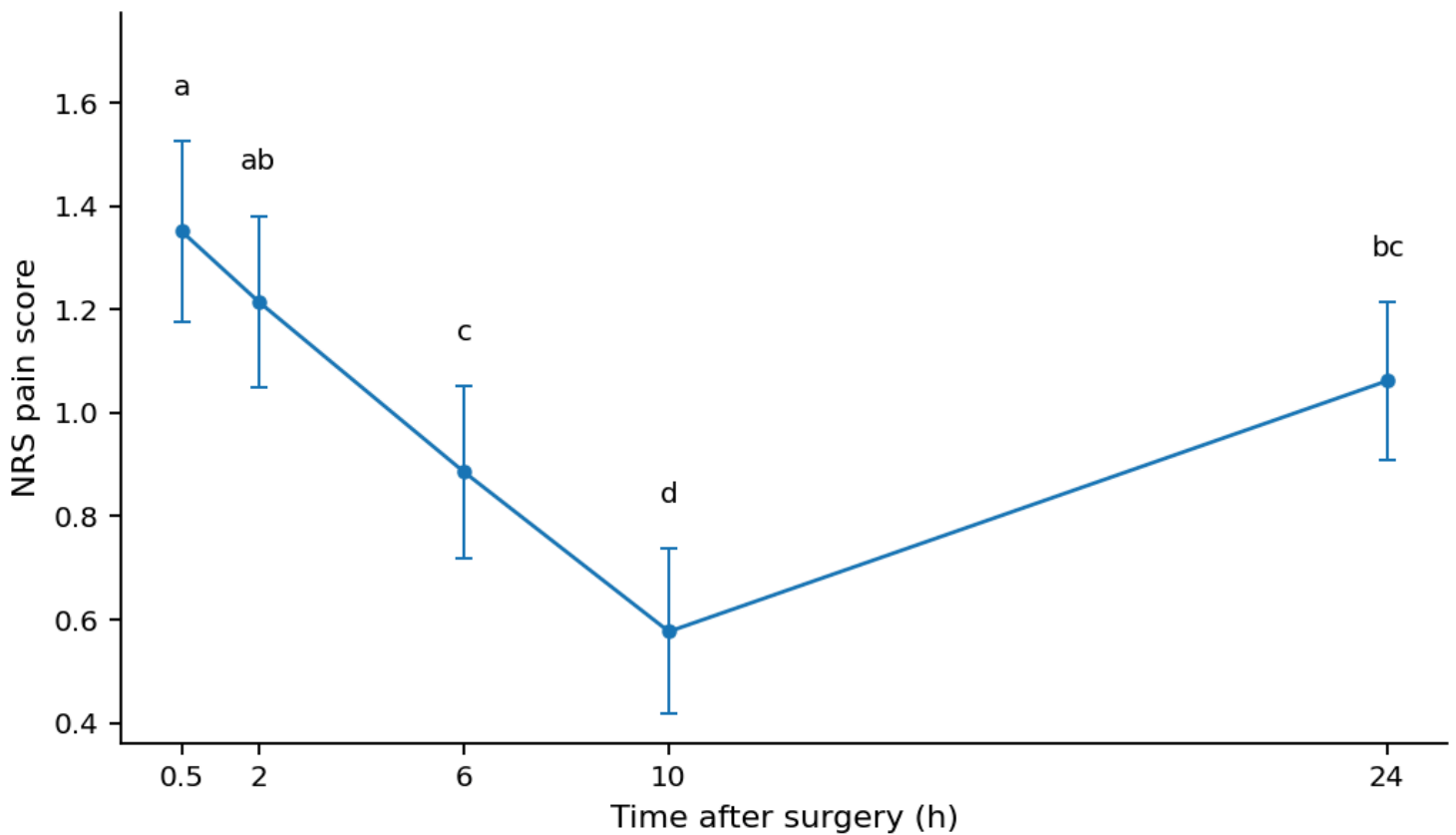


Figure 1

Postoperative NRS pain score trajectory over 24 h

Postoperative pain intensity at five time points (0.5, 2, 6, 10, and 24 h) in 202 adults undergoing ambulatory strabismus correction under general anesthesia. Points represent estimated marginal means derived from a generalized estimating equation model; vertical bars indicate 95% confidence intervals. The x-axis is scaled to reflect actual temporal spacing. Pain scores declined from 0.5 h to 10 h and increased again at 24 h.

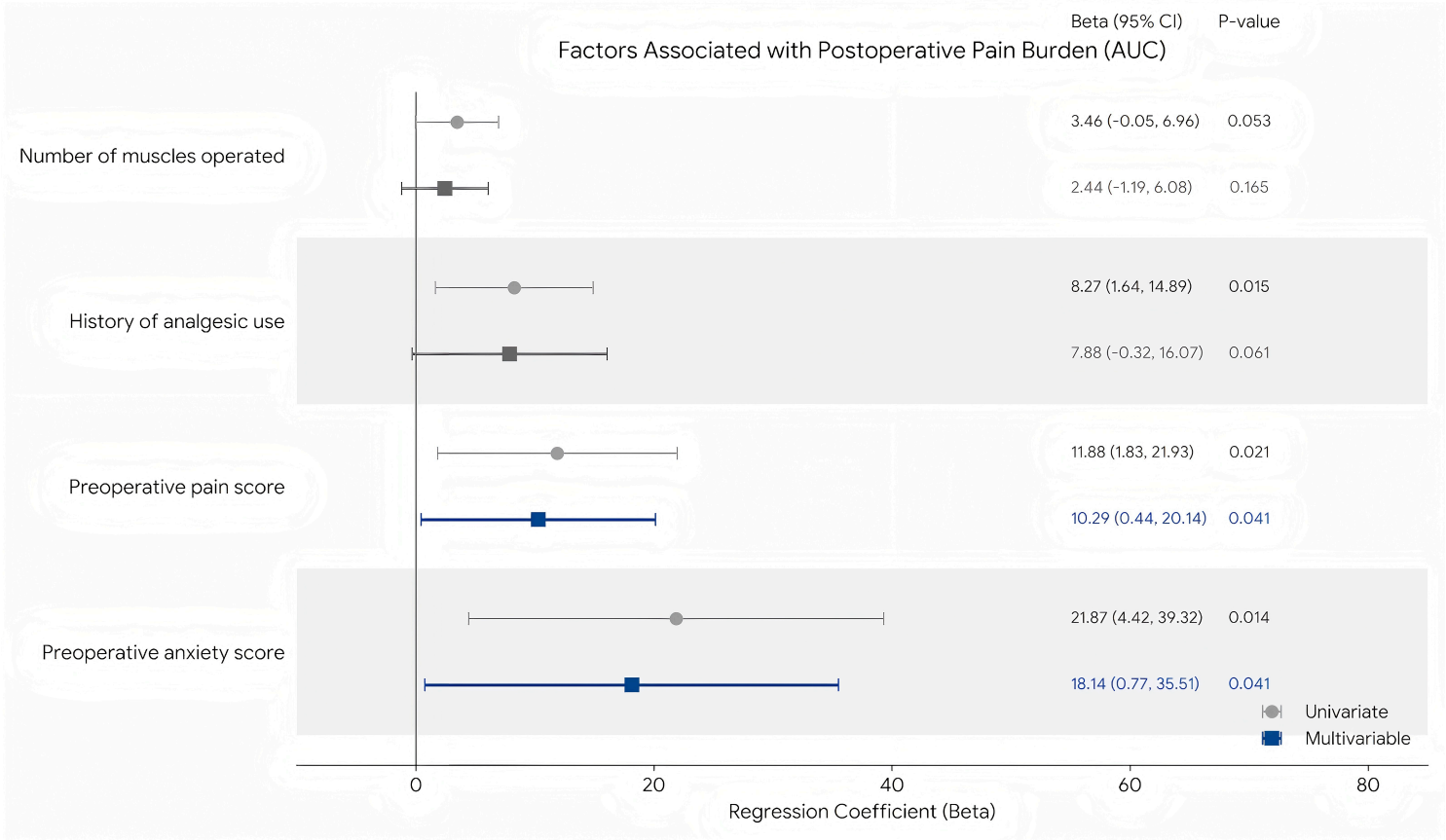


Figure 2

Predictors of postoperative pain burden

Forest plot displaying unstandardized regression coefficients and 95% confidence intervals from univariable and multivariable linear regression analyses. The outcome is cumulative postoperative pain burden from 0.5 to 24 h, quantified as AUC in NRS.h. Multivariable estimates use HC3 heteroscedasticity-robust standard errors.

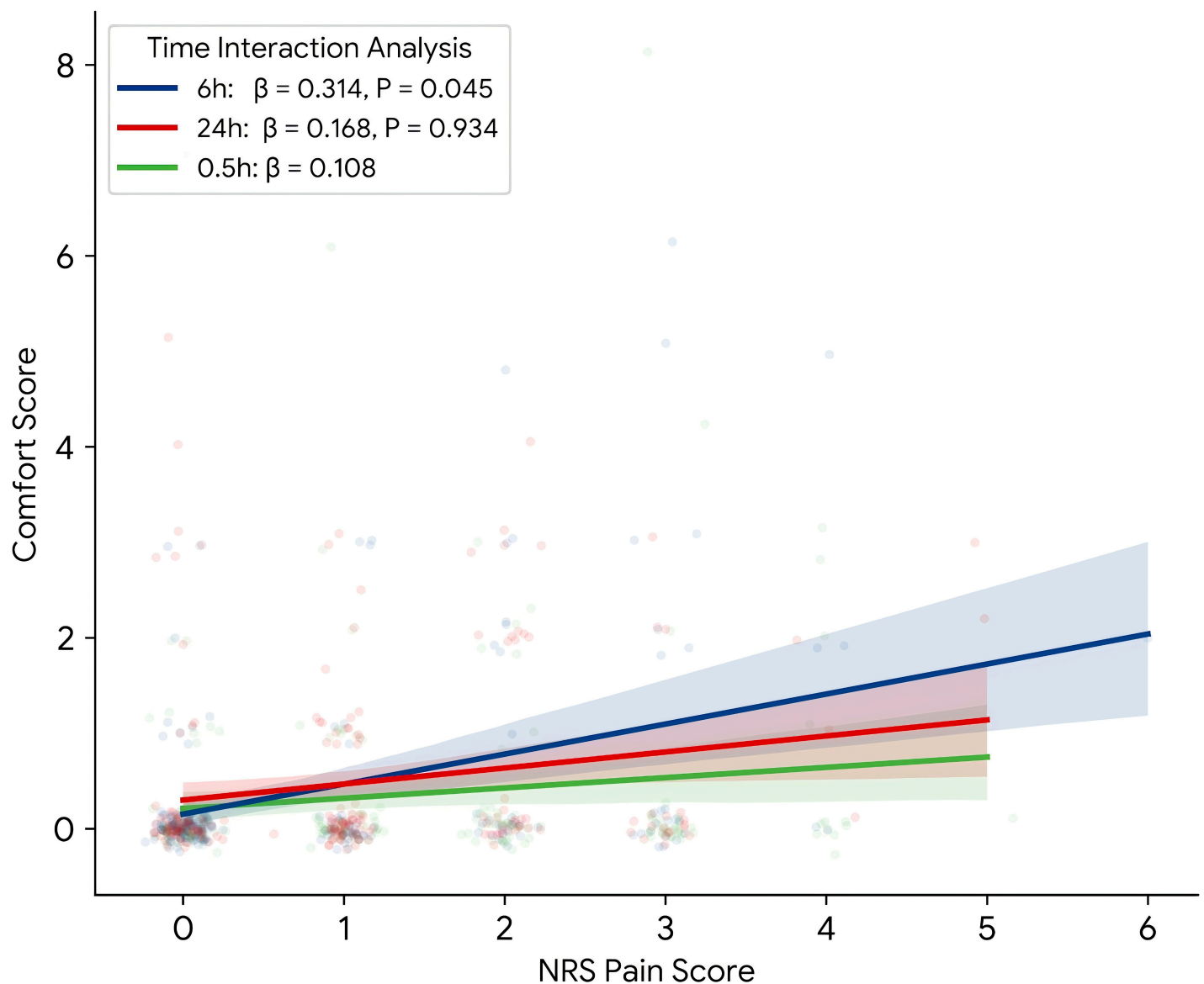


Figure 3

Time-varying association between pain and comfort

Scatter plot with fitted regression lines showing the association between NRS pain score and comfort score at selected postoperative intervals. The plot is descriptive; full adjusted interaction estimates for all five time points are reported in Table 4. The 0.5, 6, and 24 h time points were selected to show the reference interval, the strongest mid-recovery association, and the late post-discharge interval.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryFigureS1STROBEflowdiagram.tif](#)
- [SupplementaryTableS1.docx](#)