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Preoperative emotional stress and postoperative pain after lumbar fusion surgery: secondary analysis of a randomized trial of adjunctive S-ketamine in oxycodone patient-controlled analgesia

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Abstract

Background

Acute postoperative pain after lumbar fusion surgery varies considerably despite standardized multimodal analgesia. Psychological vulnerability may contribute to unfavorable pain trajectories, but brief preoperative risk assessment tools remain insufficiently evaluated.

Methods

We conducted a secondary analysis of the randomized DoseRespKeta trial of adjunctive S-ketamine in oxycodone patient-controlled analgesia after lumbar fusion surgery. Preoperative emotional stress was assessed using the Brief Measure of Emotional Preoperative Stress (B-MEPS) and analyzed as a standardized latent trait. The primary outcome was the association between preoperative emotional stress and severe postoperative pain (NRS ≥ 7) during the first 72 postoperative hours, using mixed-effects logistic regression. The secondary outcome was cumulative oxycodone consumption during the first 24 postoperative hours.

Results

Of the 100 patients completing the parent trial, 98 had complete B-MEPS and postoperative outcome data. A one-unit increase in preoperative emotional stress was associated with severe pain at rest (NRSR ≥ 7; OR 2.73 [95% CI 1.20–6.24], p = 0.017) and during movement (NRSM ≥ 7; OR 2.52, [95% CI 1.29–4.92], p = 0.007) during the first 72 hours. In contrast, preoperative emotional stress was not independently associated with cumulative 24-hour oxycodone consumption (β 4.58 mg per one-unit increase in standardized emotional stress, 95% CI − 4.37–13.53, p = 0.319).

Conclusions

Preoperative emotional stress assessed using the B-MEPS was associated with less favorable postoperative pain trajectories despite standardized multimodal analgesia. These findings suggest that preoperative emotional stress is a marker of vulnerability within a biopsychosocial recovery process but do not validate the B-MEPS as a clinical prediction tool.

Trial registration

The study was registered before patient enrollment at clinicaltrials.gov (NCT02994173; Principal investigator: Teijo I. Saari; Date of registration: November 11, 2016) and in the EudraCT database (2016–002887–14; Principal investigator: Teijo I. Saari; Date of registration: October 12, 2016).

1. BACKGROUND

Severe acute postoperative pain remains one of the most common adverse outcomes after surgery. Despite standardized perioperative care and multimodal analgesia, postoperative pain trajectories vary substantially [1–4]. Recent studies have identified distinct postoperative pain trajectories associated with subsequent clinical outcomes. These observations support viewing postoperative pain as part of the overall recovery process rather than an isolated symptom [5].

Major spinal surgery is particularly associated with severe postoperative pain [6], yet the determinants of this variability remain incompletely understood. Psychological factors such as anxiety, depression, catastrophizing, and emotional distress have consistently been associated with more severe postoperative pain, delayed recovery, and persistent pain after lumbar spine surgery [7–9]. Psychological distress has also been associated with increased postoperative opioid requirements and greater analgesic consumption after spine surgery [10–11].

Postoperative recovery is increasingly understood within a biopsychosocial framework in which psychological, biological, and social factors interact. Within this framework, anxiety, depression, and maladaptive coping may identify patients with greater vulnerability to poor postoperative recovery [12–14]. Practical tools for identifying psychologically vulnerable patients before surgery remain limited. Most available instruments assess individual psychological constructs such as anxiety or depression [9–10]. Because postoperative pain vulnerability is multidimensional, no single construct is likely to capture it adequately. This has motivated the development of brief instruments designed to assess emotional preoperative stress more comprehensively.

Caumo et al. [15] developed the Brief Measure of Emotional Preoperative Stress (B-MEPS), an instrument designed to assess preoperative stress. Unlike instruments focusing on single psychological domains, the B-MEPS was developed to assess emotional preoperative stress as a latent construct. The instrument was subsequently refined and showed promising associations with acute postoperative pain in an independent surgical cohort [16]. However, external evaluations remain limited, particularly in standardized perioperative settings that minimize treatment-related variability.

We performed a secondary analysis of the previously reported DoseRespKeta trial (ClinicalTrials.gov NCT02994173), a randomized controlled trial with standardized perioperative care and randomized adjunctive S-ketamine treatment [17]. The standardized trial design minimized treatment-related variability. We examined whether preoperative emotional stress measured with the B-MEPS was associated with postoperative pain trajectories during the first 72 hours after lumbar fusion surgery. We also examined its association with cumulative 24-hour oxycodone consumption.

2. MATERIALS AND METHODS

2.1. Ethics and registration

The parent DoseRespKeta trial was approved by the Institutional review board of the Hospital District of Southwest Finland (103/1800/2016) and the Finnish Medicines Agency (FIMEA, KL 135/2016). The study was registered before patient enrollment at clinicaltrials.gov (NCT02994173; Principal investigator: Teijo I. Saari; Date of registration: November 11, 2016) and in the EudraCT database (2016–002887–14; Principal investigator: Teijo I. Saari; Date of registration: October 12, 2016). All participants provided written informed consent. No protocol amendments relevant to the present analysis were made after study initiation. The trial was conducted between February 2017 and May 2021 at Turku University Hospital, and at Helsinki University Hospital.

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to assist with language editing and improving readability. The authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

2.2. Study design

This study is a prespecified secondary analysis of the previously published DoseRespKeta trial [17], a randomized, double-blinded, and placebo-controlled study evaluating adjunctive S-ketamine in oxycodone patient-controlled analgesia (PCA) after lumbar spinal fusion surgery. Preoperative emotional stress was included among the secondary assessments in the original trial protocol. The objective was to evaluate whether preoperative emotional stress assessed using the Brief Measure of Emotional Preoperative Stress (B-MEPS) was associated with postoperative pain trajectories and opioid consumption during the early postoperative period.

Adult patients undergoing elective lumbar spinal fusion surgery were enrolled in the parent trial and randomized to receive oxycodone PCA either alone or combined with one of three randomized S-ketamine treatments for 72 hours postoperatively. Details of the original trial design, intervention protocol, and primary outcomes have been reported previously [17]. The original trial protocol is available from the corresponding author upon reasonable request.

2.3. Preoperative stress measurement

All participants completed the B-MEPS questionnaire during the preoperative visit. The B-MEPS was originally developed to quantify emotional stress related to an upcoming surgical procedure and to identify patients at increased risk of moderate-to-severe postoperative pain [15]. The revised 12-item version of the instrument was used in the present analysis. Three items removed during the subsequent psychometric refinement of the instrument were excluded from the original questionnaire responses prior to analysis [16]. The retained items and scoring procedure are provided in the Supplementary Methods and Supplementary Table S1.

Preoperative emotional stress was modeled as a latent trait using an Item Response Theory (IRT) framework. Item parameters were fixed to those previously reported by Schiavo et al. [16] and individual latent trait estimates were obtained from the observed response patterns. The objective was not to

recalibrate or revalidate the instrument but to evaluate whether previously established B-MEPS parameters were associated with postoperative pain outcomes in an independent surgical cohort.

2.4. Postoperative pain assessment

Postoperative pain intensity was assessed using the Numeric Rating Scale (NRS; range 0–10), where 0 indicates no pain and 10 the worst pain imaginable. Pain was evaluated both at rest and during movement throughout the first 72 postoperative hours. For the primary analysis, postoperative pain at rest was assessed at 4, 8, 24, 48, and 72 hours after surgery. Earlier measurements obtained during the immediate recovery period were excluded because pain ratings during emergence from anesthesia were considered less clinically informative and demonstrated substantial short-term variability. Severe postoperative pain was defined a priori as an NRS score ≥ 7.

2.5. Outcomes

The primary outcome was severe postoperative pain at rest (NRSR ≥ 7) measured repeatedly during the first 72 postoperative hours. The primary objective was to evaluate its association with preoperative emotional stress using longitudinal mixed-effects logistic regression. The secondary outcome was cumulative oxycodone consumption during the first 24 postoperative hours.

2.6. Covariates

Potential confounders were selected a priori based on previous literature and clinical relevance (18,19). These included age, sex, preoperative pain intensity at rest, chronic pain status, preoperative opioid or gabapentinoid use, body mass index, and exposure to S-ketamine within the randomized trial. Due to convergence limitations related to model complexity relative to sample size and event frequency, the final mixed-effects models were restricted to age, sex, baseline pain intensity, and time.

2.7. Statistical analysis

Continuous variables are presented as mean (standard deviation) or median (interquartile range), as appropriate. Categorical variables are presented as counts and percentages. Normality of continuous variables was assessed visually using histograms and quantile-quantile plots. Preoperative emotional stress (PES) was estimated with ltm R package (version 1.2-0). Individual latent trait estimates were subsequently used as continuous predictors in all regression analyses.

The primary analysis evaluated the association between preoperative emotional stress and postoperative pain trajectories using mixed-effects logistic regression. Severe pain (NRS ≥ 7) was used as the dependent variable. Repeated pain assessments were nested within individuals, and a random intercept was included to account for within-subject correlation. Time was modeled as a categorical variable because measurement intervals were unequally spaced. Separate models were fitted for pain at rest (NRSR) and movement-evoked pain (NRSM).

Secondary analyses consisted of logistic regression models evaluating associations between preoperative emotional stress and severe postoperative pain within prespecified postoperative

observation windows (4–24 h, 4–48 h, and 4–72 h). The secondary outcome, cumulative 24-hour oxycodone consumption, was analyzed using linear regression. Model assumptions were assessed by visual inspection of residual diagnostics. Additional exploratory analyses were performed to examine associations between preoperative emotional stress, baseline patient characteristics, and perioperative variables.

All statistical tests were two-sided. Associations are reported as effect estimates with corresponding 95% confidence intervals, and a p-value < 0.05 was considered statistically significant. Analyses were performed using R version 4.5.0 (R Foundation for Statistical Computing, Vienna, Austria), and data visualization was performed using the package ggplot2 version 3.5.2.

3. RESULTS

A total of 107 patients were enrolled in the DoseRespKeta trial. Patient flow through the original randomized trial has been reported previously by Brinck et al.[17], and the original CONSORT flow diagram is reproduced in Supplementary Figure S1. Two patients withdrew after randomization. Of the remaining 105 randomized patients, five were excluded after randomization because of a change in surgical procedure (n = 1), organizational reasons (n = 2), or withdrawal of consent during the first postoperative 24 hours (n = 2). Consequently, 100 patients completed the original trial, and 98 patients (53 men, 45 females, median age [IQR] 60 [50.3–68]) with complete B-MEPS and postoperative outcome data were included in the present secondary analysis.

3.1. Descriptive statistics

Baseline characteristics according to randomized treatment group are presented in Table 1. The study population consisted predominantly of patients with chronic pain, though preoperative opioid use was not common. Demographic and clinical characteristics, including the latent preoperative emotional stress score, were generally balanced across treatment groups.

Table 1
Baseline characteristics of the study population. Baseline characteristics are presented according to randomized treatment group. P-values compare characteristics across the four randomized treatment groups.

Characteristic	All	G1: Oxycodone 1 mg/ml	G2: Oxycodone 1 mg/ml + S-ketamine 0.25 mg/ml	G3: Oxycodone 1 mg/ml + S-ketamine 0.5 mg/ml	G4: Oxycodone 1 mg/ml + S-ketamine 0.75 mg/ml	p-value*
n	98	25	23	25	25	
Age (yr; median, range)	60 (28, 78)	56 (34, 78)	62 (28, 76)	60 (41, 75)	62 (30, 76)	0.492[1]
Sex (n; female/male)	45/53	11/14	11/12	11/14	12/13	0.985[2]
BMI (kg/m^2)	26.9 (4.2)	26.6 (4.6)	26.8 (4.7)	27.3 (4.3)	26.9 (3.5)	0.952[3]
Previous chronic pain (n; yes/no)	82/16	22/3	19/4	19/6	22/3	0.655[2]
Preoperative pain at rest (NRSR; median, IQR)	4.5 (3, 5)	5 (3.5, 6)	4 (3, 5)	3 (2.25, 5)	5 (3,5)	0.235[1]
Preoperative pain in move (NRSM; median, IQR)	6 (5, 7)	6 (5, 7)	7 (5, 8)	5 (4.3, 6.8)	7 (5, 7.5)	0.369[1]
Preop. opioid in use (n; yes/no)	5/93	2/23	1/22	2/23	0/25	0.652[2]
Preoperative emotional stress (mean, SD)	-0.42 (0.77)	-0.35 (0.87)	-0.44 (0.68)	-0.53 (0.67)	-0.36 (0.86)	0.825[3]
*						
[1]Kruskal-Wallis, [2]Fisher, [3]One-Way Anova						

----Table 1 here----

3.2. Preoperative stress and acute postoperative pain trajectory

The primary mixed-effects logistic regression analysis showed that higher preoperative emotional stress was associated with increased odds of severe postoperative pain during early postoperative hours (Table 2). Detailed mixed-effects model results are presented in Supplementary Tables S2A and S2B. Figure 1 illustrates postoperative pain trajectories according to preoperative emotional stress during the first 72 postoperative hours.

Table 2
Association between preoperative emotional stress and severe postoperative pain in mixed-effects logistic regression models

Variable	**NRSR (4-24h)**		**NRSM (4-24h)**	
	OR (95% CI)[1]	**p-value**	**OR (95% CI)**	**p-value**
Preoperative emotional stress[2]	2.68 (1.02–7.02)	0.046	2.00 (1.03, 3.91)	0.041
Age	1.04 (0.98–1.10)	0.244	0.98 (0.94, 1.02)	0.398
Sex	0.33 (0.07–1.53)	0.158	0.52 (0.19, 1.38)	0.188
Preoperative NRSR pain	1.13 (0.79–1.61)	0.499		
Preoperative NRSM pain			0.96 (0.76, 1.21)	0.737
Time (8 h vs 4 h)[3]	3.30 (0.79–13.82)	0.102	3.43 (1.45, 8.13)	0.005
Time (24 h vs 4 h)[3]	2.78 (0.66–11.72)	0.164	4.83 (1.97, 11.80)	0.001
[1]Odds ratios are from mixed-effects logistic regression models with severe pain as the dependent variable, preoperative emotional stress as a continuous latent trait predictor, categorical time, and a random intercept for participant. Sex was coded as 0 = female and 1 = male.				
[2]Odds ratios for preoperative emotional stress correspond to a one-unit increase in the standardized latent stress score and for continuous covariates to a one-unit increase in the respective variable.				
[3]Time effects represent odds ratios relative to the reference time point of 4 hours postoperatively.				
CI, confidence interval; NRSR, Numerical rating scale (pain at rest); NRSM, Numerical rating scale (movement-evoked pain); OR, odds ratio				

Prespecified observation-window analyses yielded consistent findings for both NRSR and NRSM. A one-unit increase in preoperative emotional stress was associated with higher odds of severe pain at rest (NRSR ≥ 7) during the first 4–24 postoperative hours (OR 2.68, 95% CI [1.02, 7.02], p = 0.046), 4–48 hours

(OR 2.73, 95% CI [1.16, 6.40], p = 0.021), and 4–72 hours (OR 2.73, 95% CI [1.20, 6.24], p = 0.017). Similar associations were observed for severe movement-evoked pain (NRSM ≥ 7), with odds ratios of 2.00, 95% CI [1.03, 3.91], (p = 0.041), 2.44, 95% CI [1.18, 5.06] (p = 0.017), and 2.52, [1.29, 4.92] (p = 0.007) for the 4–24, 4–48, and 4–72 hour observation windows, respectively (Supplementary Table S3 and Figure S2).

Preoperative emotional stress was analyzed as a continuous latent trait estimate, and the reported odds ratios therefore correspond to a one-unit increase in the standardized stress score.

----Table 2 here----

3.3. Association of preoperative stress with cumulative oxycodone consumption during the first 24 postoperative hours

Associations between preoperative emotional stress and cumulative oxycodone consumption during the first 24 postoperative hours were evaluated using linear regression models of increasing complexity (Table 3). In the unadjusted analysis, preoperative emotional stress was not associated with cumulative oxycodone consumption during the first 24 postoperative hours (β 3.63 mg, p = 0.446). For preoperative emotional stress, β corresponds to a one-unit increase in the standardized latent stress score. Similarly, preoperative emotional stress was not independently associated with oxycodone consumption in the fully adjusted model (β 4.58 mg, p = 0.319).

Table 3
Association between preoperative emotional stress and cumulative 24-hour oxycodone consumption.

Variable	Unadjusted		Fully adjusted	
	β (95% CI)	p	β (95% CI)	p
Preoperative emotional stress	3.63 (-5.68, 12.95)	0.446	4.58 (-4.37, 13.53)	0.319
Age			−1.22 (-1.79, -0.64)	< 0.001
Sex			14.29 (-0.07, 28.65)	0.055
Preoperative NRSR			3.14 (-0.36, 6.63)	0.082
Chronic pain			-1.46 (-20.94, 18.01)	0.883
Preoperative opioid use			-13.91 (-50.79, 22.96)	0.462
Preoperative gabapentinoid use			7.87 (-11.77, 27.51)	0.435
BMI			0.63 (-1.07, 2.32)	0.47
S-ketamine exposure			0.32 (0.02, 0.62))	0.038
Regression coefficients represent the change in cumulative oxycodone consumption (mg) associated with a one-unit increase in the corresponding predictor while holding other covariates constant, and for preoperative emotional stress to a one-unit increase in the standardized latent stress score. Sex was coded as 0 = female and 1 = male.				
BMI, Body mass index; CI, confidence interval; NRSR, numerical rating scale (pain at rest)				

In the adjusted model, younger age was associated with higher oxycodone consumption (β − 1.22 mg per year, p < 0.001), whereas greater cumulative S-ketamine exposure was associated with higher oxycodone consumption (β 0.32, p = 0.038). Preoperative pain intensity at rest showed a positive but statistically nonsignificant association with oxycodone consumption (β 3.14, p = 0.082). Full regression model outputs are presented in Supplementary Table S4.

----Table 3 here----

3.4. Exploratory analyses

Exploratory analyses showed no significant associations between preoperative emotional stress and age, body mass index, preoperative pain intensity, chronic pain, preoperative opioid use, preoperative gabapentinoid use, smoking status, diabetes, or ASA physical status classification. Higher preoperative emotional stress was associated with lower patient satisfaction with postoperative analgesia at 72 hours (p = 0.026), whereas no association was observed at 24 or 48 hours (Supplementary Table S5).

4. DISCUSSION

In this secondary analysis, higher preoperative emotional stress measured using the B-MEPS was associated with severe postoperative pain during the first 72 postoperative hours after lumbar fusion surgery. This association remained consistent in longitudinal mixed-effects analyses of repeated pain measurements. In contrast, preoperative emotional stress was not independently associated with adjusted cumulative 24-hour oxycodone consumption.

The present findings emphasize that postoperative pain should be evaluated longitudinally rather than at a single postoperative time point. Recent studies have identified distinct postoperative pain trajectories associated with subsequent recovery outcomes [5, 18]. In our study, the association between preoperative emotional stress and severe postoperative pain remained consistent across the predefined postoperative observation windows. The magnitude of the association remained relatively stable across all observation windows, indicating that the relationship between preoperative emotional stress and postoperative pain was not restricted to the immediate postoperative period. This suggests that preoperative emotional stress is associated with the overall postoperative pain course rather than pain intensity in an individual postoperative assessment.

Our findings are consistent with previous studies demonstrating associations between psychological vulnerability and postoperative pain after spine surgery. Anxiety, depression, pain catastrophizing, and psychosocial distress have all been associated with increased postoperative pain intensity and poorer functional outcomes following lumbar surgery [7–9]. Psychological factors have also been associated with postoperative opioid consumption [20]. Most available instruments assess individual psychological constructs such as anxiety or depression [19, 21], whereas the B-MEPS was developed to assess emotional preoperative stress as a multidimensional latent construct [15, 16]. Our findings extend previous work by demonstrating the same association in a standardized perioperative setting. The randomized trial design and standardized analgesic protocol reduce the likelihood that differences in perioperative management explain the observed association. The association remained after adjustment for baseline pain, age, sex, and time, suggesting that preoperative emotional stress provides information beyond routinely assessed clinical characteristics.

The observed association between preoperative emotional stress and postoperative pain is biologically and clinically plausible. Postoperative recovery is increasingly understood within a biopsychosocial framework in which psychological, biological, and social factors interact [12–14]. Emotional stress may influence postoperative pain through several psychological and physiological mechanisms. However, the present findings do not imply that emotional stress directly causes postoperative pain. Instead, preoperative emotional stress may represent a marker of vulnerability associated with less favorable postoperative recovery [12–14].

In contrast to postoperative pain intensity, preoperative emotional stress was not independently associated with cumulative 24-hour oxycodone consumption after adjustment for relevant covariates. This finding is unsurprising because opioid consumption during PCA reflects more than pain intensity

alone. It is also influenced by patient behavior, opioid sensitivity, adverse effects, and the clinical context. Furthermore, postoperative pain intensity and opioid consumption are related but distinct outcomes. Recent systematic evidence similarly suggests that their predictors overlap only partially, indicating that opioid consumption should not be interpreted as a direct surrogate for pain intensity [22].

From a clinical perspective, a brief assessment of preoperative emotional stress may help identify patients who are more likely to experience consistently severe postoperative pain after lumbar fusion surgery. Such information could support individualized perioperative counseling, optimization of multimodal analgesia, and targeted perioperative support [12–14, 22]. These findings support the role of preoperative psychological assessment as part of perioperative care [23]. Brief psychological interventions have been shown to reduce postoperative pain and improve recovery [24–26], and app-based implementation of the B-MEPS may facilitate their integration into routine preoperative assessment [16]. Current evidence suggests that multidisciplinary strategies that combine psychological and physiological protocols would enhance patients' postoperative recovery [27, 28]. Nevertheless, the present findings do not establish the B-MEPS as a validated clinical prediction tool, and it should not be used in isolation for clinical decision-making.

A major strength of this study is that the B-MEPS was evaluated in an independent cohort with highly standardized perioperative management and repeated postoperative pain assessments. The homogeneous surgical population reduced clinical heterogeneity and strengthened the interpretation of the observed association. Repeated pain measurements also allowed assessment of the association over time rather than at a single postoperative time point.

Several limitations should be acknowledged. First, this was a secondary analysis, and the original trial was not designed specifically to evaluate associations between preoperative emotional stress and postoperative pain outcomes. Second, the parent trial was powered for its primary endpoint rather than these secondary analyses. Third, residual confounding cannot be excluded despite multivariable adjustment. The findings are limited to patients undergoing lumbar fusion surgery and may not generalize to other surgical populations. Finally, the study evaluated associations rather than predictive performance and therefore does not constitute a formal validation of the B-MEPS as a clinical prediction tool.

Conclusions

In conclusion, higher preoperative emotional stress measured using the B-MEPS was associated with severe postoperative pain during the first 72 postoperative hours after lumbar fusion surgery. These findings suggest that preoperative emotional stress is a marker of vulnerability to poorer postoperative recovery rather than supporting the B-MEPS as a stand-alone clinical prediction tool. Further prospective studies are needed to define its role in preoperative risk assessment.

Abbreviations

AIC, Akaike information criterion, ASA, American Society of Anesthesiologists, B-MEPS, Brief Measure of Emotional Preoperative Stress, BIC, Bayesian information criterion, BMI, body mass index, CI, confidence interval, IRT, item response theory, NRS, numerical rating scale, NRSM, numerical rating scale for movement-evoked pain, NRSR, numerical rating scale for pain at rest, OR, odds ratio, PCA, patient-controlled analgesia, PES, preoperative emotional stress, RCT, randomized controlled trial, SD, standard deviation

Declarations

Funding

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Ethics approval and consent to participate

The original trial was approved by the Institutional review board of the Hospital District of Southwest Finland (103/1800/2016) and the Finnish Medicines Agency (FIMEA, KL 135/2016). All participants provided written informed consent.

Availability of data and materials

The patient-level data underlying this study are not publicly available owing to regulatory and confidentiality restrictions applicable to the original clinical trial. The data that support the findings of this study are available on request from the corresponding author.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable

Authors' contributions

Taru Virtanen: Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Akseli Lehtimäki**: Formal analysis, Methodology, Validation, Visualization, Writing – review & editing. **Elina C.V. Brinck**: Conceptualization, Data curation, Investigation, Writing – review & editing. **Pekka Tarkkila**, Investigation, Writing – review & editing. **Vesa Kontinen**: Investigation, Writing – review & editing. **Kari Auranen**: Formal analysis, Methodology, Validation, Writing – review & editing. **Marko Peltoniemi**: Conceptualization, Investigation, Resources, Writing – review & editing. **Teijo I. Saari**: Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – review & editing. All authors read and approved the final manuscript.

References

1. Gan TJ, Habib AS, Miller TE, et al. Incidence, patient satisfaction, and perceptions of post-surgical pain: Results from a US national survey. Curr Med Res Opin. 2014;30(1):149–60.
2. Apfelbaum JL, Chen C, Mehta SS, et al. Postoperative pain experience: results from a national survey suggest postoperative pain continues to be undermanaged. Anesth Analg. 2003;97(2):534–40.
3. Sauaia A, Min S, Leber C, et al. Postoperative pain management in elderly patients: correlation between adherence to treatment guidelines and patient satisfaction. J Am Geriatr Soc. 2005;53(2):274–82.
4. Zachodnik J, Bech-Azeddine R, Sandberg M, et al. Postoperative Pain Management After Lumbar Discectomy. A Systematic Review With Meta- Analyses and Trial Sequential Analyses. Eur J Pain. 2026;30(4):e70261.
5. Awadalla SS, Winslow V, Avidan MS, et al. Effect of acute postsurgical pain trajectories on 30-day and 1-year pain. PLoS ONE. 2022;17(6):e0269455.
6. Lamperti M, Tufegdzic B, Avitsian R. Management of complex spine surgery. Curr Opin Anaesthesiol. 2017;30(5):551–6.
7. Kim H-J, Kwon OH, Chang B-S, et al. Change in pain catastrophizing in patients with lumbar spinal surgery. Spine J. 2018;18(1):115–21.
8. Coronado RA, George SZ, Devin CJ, et al. Pain Sensitivity and Pain Catastrophizing Are Associated With Persistent Pain and Disability After Lumbar Spine Surgery. Arch Phys Med Rehabil. 2015;96(10):1763–70.
9. Amaral V, Marchi L, Martim H, et al. Influence of psychosocial distress in the results of elective lumbar spine surgery. J Spine Surg. 2017;3(3):371–8.
10. Anderson JT, Haas AR, Percy R, et al. Clinical depression is a strong predictor of poor lumbar fusion outcomes among workers' compensation subjects. Spine (Phila Pa 1976). 2015;40(10):748–56.
11. Mendoza-Elias N, Dunbar M, Ghogawala Z, et al. Opioid Use, Risk Factors, and Outcome in Lumbar Fusion Surgery. World Neurosurg. 2020;135:e580–7.
12. Glare P, Aubrey KR, Myles PS. Transition from acute to chronic pain after surgery. Lancet. 2019;393(10180):1537–46.
13. Beeckman M, Hughes S, Van Der Kaap-deeder J, et al. Risk and Resilience Predictors of Recovery After Spinal Fusion Surgery in Adolescents. Clin J Pain. 2021;37(11):789–802.
14. Giusti EM, Lacerenza M, Manzoni GM, et al. Psychological and psychosocial predictors of chronic postsurgical pain: a systematic review and meta-analysis. Pain. 2021;162(1):10–30.
15. Caumo W, Nazare Furtado da Cunha M, Camey S, et al. Development, psychometric evaluation and validation of a brief measure of emotional preoperative stress (B-MEPS) to predict moderate to intense postoperative acute pain. Br J Anaesth. 2016;117(5):642–9.
16. Schiavo CL, Borges RB, Castro SMJ, et al. Measuring emotional preoperative stress by an app approach and its applicability to predict postoperative pain. PLoS ONE. 2022;17(2):e0263275.

17. Brinck ECV, Virtanen T, Mäkelä S, et al. S-ketamine in patient-controlled analgesia reduces opioid consumption in a dose-dependent manner after major lumbar fusion surgery: A randomized, double-blind, placebo-controlled clinical trial. PLoS ONE. 2021;16(6):e0252626.
18. Ip HYV, Abrishami A, Peng PWH, et al. Predictors of Postoperative Pain and Analgesic Consumption: a qualitative systematic review. Anesthesiology. 2009;111(3):657–77.
19. Dunn L, Durieux M, Fernández L, et al. Influence of catastrophizing, anxiety, and depression on in-hospital opioid consumption, pain, and quality of recovery after adult spine surgery. J Neurosurg Spine. 2018;28(1):119–26.
20. Tapar H, Özsoy Z, Gürler M, et al. Associations between postoperative analgesic consumption and distress tolerance, anxiety, depression, and pain catastrophizing: a prospective observational study. Brazilian J Anesthesiol. 2022;72(5):567–73.
21. Kent ML, Giordano NA, Rojas W, et al. Multidimensional Perioperative Recovery Trajectories in a Mixed Surgical Cohort: A Longitudinal Cluster Analysis Utilizing National Institutes of Health Patient-Reported Outcome Measurement Information System Measures. Anesth Analg. 2022;134(2):279–90.
22. Folkersen CR, Rasmussen IH, Sunde PB, et al. Related Predictors of Opioid Use, Pain and Related Adverse Events in the First 24 h After Surgery : A Systematic Review and Meta- Analysis. Eur J Pain. 2026;30(3):e70242.
23. Von Plato H, Mattila K, Poikola S, et al. Risk-based targeting of adjuvant pregabalin treatment in laparoscopic cholecystectomy: A randomized, controlled trial. Scand J Pain. 2019;19(2):309–17.
24. Hall A, Nguyen N, Cascavita C, et al. The Impact of Psychological Prehabilitation on Surgical Outcomes. Ann Surg. 2025;281(6):928–41.
25. Darville-Beneby R, Lomanowska A, Yu H, et al. The Impact of Preoperative Patient Education on Postoperative Pain, Opioid Use, and Psychological Outcomes: A Narrative Review. Opioid Use. Can J Pain. 2023;7(2):2266751.
26. Darnall B, Abshire L, Courtney R, et al. Upskilling pain relief after surgery: a scoping review of perioperative behavioral intervention efficacy and practical considerations for implementation. Reg Anesth Pain Med. 2025;50(2):93–101.
27. Wang R, Huang X, Wang Y, et al. Non-pharmacologic Approaches in Preoperative Anxiety, a Comprehensive Review. Front Public Heal. 2022;10:854673.
28. Liu Z, Yang D. The impact of prehabilitation on postoperative outcomes in spine surgery: A systematic review and meta-analysis. J Back Musculoskelet Rehabil. 2026;39(1):18–33.

Figures

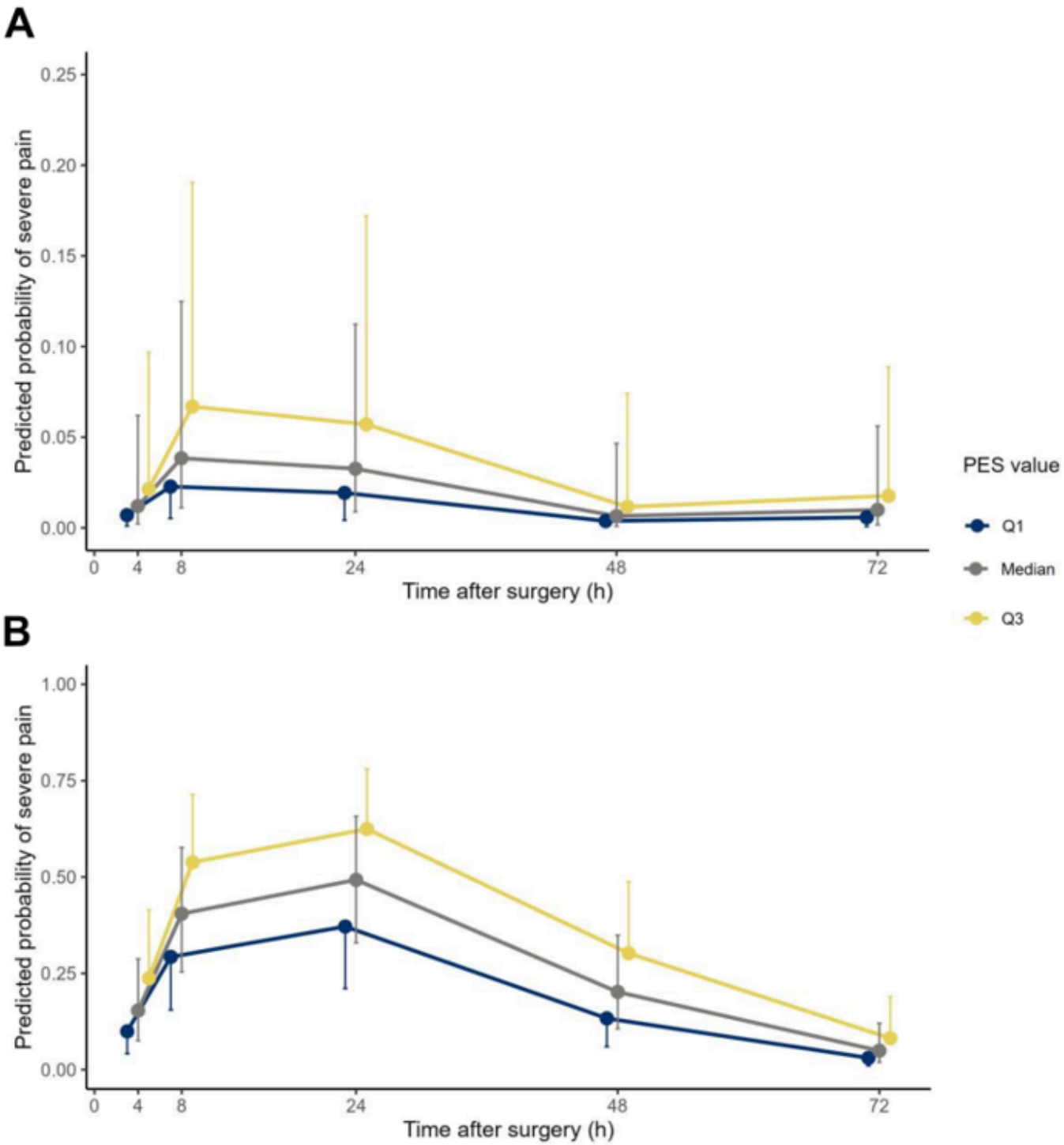


Figure 1

Predicted probability of severe postoperative pain (NRS ≥7) from mixed-effects logistic regression models according to preoperative emotional stress level. Panels show pain at rest (A) and movement-evoked pain (B) during the first 72 postoperative hours. Predicted probabilities were calculated with age and baseline pain fixed at their median values, sex averaged according to the observed study distribution, and the participant-specific random intercept set to zero. Curves represent the first quartile

(Q1), median, and third quartile (Q3) of the preoperative emotional stress distribution (-1.02, -0.49, 0.09, respectively). Error bars indicate 95% confidence intervals.

Supplementary Files

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- SupplementaryMaterial261026.pdf