

Determination of moderate-to-severe postoperative pain on the numeric rating scale: a cut-off point analysis applying four different methods

H. J. Gerbershagen^{1*}, J. Rothaug², C. J. Kalkman¹ and W. Meissner²

¹ Department of Anaesthesiology and Intensive Care, University Medical Centre Utrecht, Heidelberglaan 100, 3584 GA Utrecht, The Netherlands

² Department of Anaesthesiology and Intensive Care, University Hospital Jena, Erlanger Allee 101, 07747 Jena, Germany

* Corresponding author. E-mail: h.j.gerbershagen@umcutrecht.nl

Editor's key points

- A numeric rating scale (NRS) of 1–10 is widely used for the assessment of postoperative pain.
- In this study, a number of different methods were used to identify a cut-off value between mild and moderate pain.
- Three of the four methods used identified an NRS of 4 or more as identifying patients with moderate or severe pain.
- Postoperative pain treatment should be tailored to individual patient needs and not based on the NRS alone.

Background. Cut-off points (CPs) of the numeric rating scale (NRS 0–10) are regularly used in postoperative pain treatment. However, there is insufficient evidence to identify the optimal CP between mild and moderate pain.

Methods. A total of 435 patients undergoing general, trauma, or oral and maxillofacial surgery were studied. To determine the optimal CP for pain treatment, four approaches were used: first, patients estimated their tolerable postoperative pain intensity before operation; secondly, 24 h after surgery, they indicated if they would have preferred to receive more analgesics; thirdly, satisfaction with pain treatment was analysed, and fourthly, multivariate analysis was used to calculate the optimal CP for pain intensities in relation to pain-related interference with movement, breathing, sleep, and mood.

Results. The estimated tolerable postoperative pain before operation was median (range) NRS 4.0 (0–10). Patients who would have liked more analgesics reported significantly higher average pain since surgery [median NRS 5.0 (0–9)] compared with those without this request [NRS 3.0 (0–8)]. Patients satisfied with pain treatment reported an average pain intensity of median NRS 3.0 (0–8) compared with less satisfied patients with NRS 5.0 (2–9). Analysis of average postoperative pain in relation to pain-related interference with mood and activity indicated pain categories of NRS 0–2, mild; 3–4, moderate; and 5–10, severe pain.

Conclusions. Three of the four methods identified a treatment threshold of average pain of $\text{NRS} \geq 4$. This was considered to identify patients with pain of moderate-to-severe intensity. This cut-off was identified as the tolerable pain threshold.

Keywords: pain categories; pain cut-off; pain threshold; postoperative pain

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The numeric rating scale (NRS 0–10; 0, no pain; 10, worst pain imaginable) has been validated for measuring postoperative pain intensity.¹ This scale is often used to divide patients into groups who are in need of pain treatment (moderate and severe pain) and those who are not (mild pain). The presently used treatment threshold or cut-off point (CP) for moderate pain treatment is arbitrarily set at $\text{NRS} \geq 3$,² ≥ 4 ,³ ≥ 4 or ≥ 5 ,^{5–7} and even as high as $\text{NRS} \geq 6$ in different studies.⁸

Different CPs in protocols for acute postoperative pain management lead to variations in treatment. In addition, such CPs are increasingly regarded as a quality indicator of postoperative pain control. The wide range of CPs used in different research studies makes the comparison of results difficult. It is possible that in some study protocols, the

threshold for pain treatment was selected to achieve the desired study result.

Initial attempts to define CPs were based on the assumption that the terms mild and moderate pain could distinguish patients requiring additional pain treatment. Pain descriptors on a verbal rating scale (VRS) (mild, moderate, and severe) were matched with the corresponding pain scores of the visual analogue scale (VAS) scores (0–100 mm).⁹ ¹⁰ However, a large prospective study found a discrepancy between reports of severe pain and acceptability; 31% of patients who rated their pain as severe reported this pain as acceptable.¹¹ Thus, a simple match of the term 'moderate' on the VRS with the scores of the NRS or VAS does not seem appropriate for identifying the optimal CP, indicating a need for analgesic administration.

A different approach was introduced by Serlin and colleagues to calculate the optimal CPs for mild, moderate, and severe pain. These authors analysed the association of pain intensity with pain-related interference in activities such as movement and sleep in cancer patients. Pain interference was measured with the Brief Pain Inventory (BPI).¹² In acute postoperative pain studies, this method of calculation has only been applied twice, in a study of postoperative pain after hip- and knee-replacement surgery and after sternotomy. It is not clear if this method of calculating cut-offs between pain intensity and pain interference actually reflects the need for therapeutic intervention.

The aim of this study was to determine the optimal CPs between mild and moderate-to-severe pain intensities on the first postoperative day. There is no generally accepted gold standard to determine the optimal CP on an NRS and presently used CP analysis methods are not known to be appropriate for postoperative pain. We applied and compared four different methods in order to arrive at the most valid approach to analyse CPs.

Methods

Subjects

Data were collected following the guidelines of the QUIPS project (Quality Improvement in Postoperative Pain Management)¹³ in the departments of general surgery, traumatology, and oral and maxillofacial surgery at the University of Jena, Germany, between November 2006 and November 2007. A total of 444 patients were included in the study. Inclusion criteria were age more than 18 yr and capability to understand German. Patients were excluded if they were undergoing a repeat surgical procedure and when postoperative mechanical ventilation was planned for more than 24 h, as this was the time-point for pain assessment.¹³ There was no restriction with regard to the type of surgery. All consecutive patients fulfilling the inclusion criteria were asked to take part in this study. After approval was obtained from the University Ethics Committee, all patients gave their written informed consent before entering the study.

QUIPS questionnaire

The QUIPS project was set up to analyse postoperative pain management and to anonymously compare outcomes among participating hospitals.¹³ The standard QUIPS protocol is divided into sections dealing with (i) average and worst pain intensities during the last 24 h since surgery (NRS 0–10); (ii) pain-related interference with: physical activity (walking, movement); coughing and deep breathing, sleep, and mood during the last 24 h since surgery (NRS 0–10); (iii) pain-related awakening during the previous night; (iv) nausea or vomiting since surgery; (v) wish to have had received additional doses of pain medication during the period since surgery; (vi) patient satisfaction with postoperative analgesia recorded using a 16-box NRS (0–15, 0, very unsatisfied; 15, very satisfied). Information on the type of surgery, anaesthesia, and postoperative pain

treatment are also documented. In addition to the standard QUIPS questionnaire items, patients were asked to estimate their tolerable postoperative pain level (NRS 0–10) before operation.

Patient questionnaires were administered by study nurses who were neither associated with the particular departments nor involved in patients' care. Assessment was performed on the first postoperative day between 8 and 11 a.m.

Analysis of CPs

First, we asked patients to indicate postoperative pain thresholds before operation that they would consider 'tolerable'. Secondly, we evaluated the need for therapeutic interventions by asking patients 24 h after surgery if they would have wished to have received additional postoperative analgesia and compared the average and worst NRS scores of patients who indicated a wish to have received more analgesia to patients who did not. Thirdly, average and worst pain intensities in patients 'very satisfied' or 'satisfied' with pain treatment were compared with pain intensities in patients who were less satisfied. Fourthly, we calculated CPs between mild and moderate-to-severe postoperative pain intensities in relation to pain-related interference with movement, taking deep breaths, sleep quality, and mood.

Statistical analysis

All variables measured with the NRS are reported as median (range). This includes individual patients' estimates of their average pain which are summarized as median and range across groups of patients. The Mann–Whitney test was applied to compare postoperative pain intensities between patients with and without a wish to have received more analgesics and between patients with low and high satisfaction with pain treatment. Estimated tolerable pain before operation was compared between patients with mild and moderate-to-severe postoperative pain by means of the Mann–Whitney test.

Satisfaction with pain treatment (NRS 0–15) was graded using German school grade categories: 15–13 (very satisfied), 12–10 (satisfied), 9–7 (neither satisfied, nor dissatisfied), 6–4 (dissatisfied), and 0–3 (very dissatisfied). The scale was dichotomized in $\text{NRS} \geq 10$ (very satisfied or satisfied) vs lower scores. In all comparisons, two-sided tests were used with $P \leq 0.05$ to indicate statistical significance.

The fourth applied method to identify the optimal CP is based on the relation between average and worst postoperative pain intensity since surgery and pain-related interference with mood and activities. The statistical method described by Serlin and colleagues¹² was used. To identify the optimal CP, 28 different combinations of pain CPs from CP 1/2 to CP 7/8 of average and worst pain since surgery were analysed. The upper limits for mild and moderate pain were used to describe the CPs, for example, CPs 1–4, 5–6, 7–10 were termed CP 4/6.

The means of the four variables (interference with mood, deep breathing, sleep, and mood) were pooled to give a

total-interference score (NRS 0–10). The optimal CPs for mild, moderate, and severe pain were identified by multivariate analysis among pain-severity categories yielding the largest *F* ratio for the between-category effect on the total pain-related interference score as indicated by Pillai's trace, Wilks' λ , and Hotelling trace *F* statistics. Patients without any postoperative pain had no pain-related interferences and were excluded from the CP analysis based on between-category effects. Data were analysed using the Statistical Package for the Social Sciences (SPSS® release 18.0, Chicago, IL, USA).

Results

Patient characteristic and clinical data

Inclusion criteria were met by 444 patients. Nine patients did not complete the questionnaire, leaving 435 for further statistical analysis. Approximately 56% of the patients were male; 55%, 24%, and 21% were admitted to the

traumatology, general surgery, or oral and maxillofacial surgery departments. The most frequent surgical procedures are listed in Table 1.

Before operation evaluated 'tolerable' postoperative pain intensity, the wish to have received more analgesics, and satisfaction with pain treatment

Before surgery, patients indicated a median (range) NRS score of 4.0 (0–10) as the threshold for tolerable postoperative pain (Fig. 1).

Patients were asked on the morning after surgery if they would have wished to receive additional doses of analgesics during the period from surgery to the time of the study nurse's interview. Eight of the 435 patients did not answer this question; 75 of the remaining patients (17.6%) indicated that they would have preferred to receive more analgesics. Patients without this demand reported an average pain intensity since surgery of median NRS 3.0 (0–8), while those who would have preferred additional analgesic doses reported significantly higher pain intensity of median 5.0 (0–9) ($P \leq 0.001$) (Fig. 2). Worst pain intensity since surgery recorded on the NRS also differed significantly ($P \leq 0.001$) between these two groups: 6.0 (0–10) vs 8.0 (2–10).

Patients who graded their satisfaction with pain treatment as very satisfied or satisfied (83.7%) reported average postoperative pain intensity since surgery as NRS 3.0 (0–8) when compared with 5.0 (2–9) in the less satisfied patient group (16.3%) (Fig. 3). The two groups differed significantly

Table 1 Patient characteristic and clinical data (n=435)

	n (%)
Gender	
Female	192 (44.1)
Male	243 (55.9)
Age (yr)	
18–20	38 (8.7)
21–30	75 (17.2)
31–40	88 (20.2)
41–50	96 (22.1)
51–60	87 (20.0)
61–70	49 (11.3)
71–80	2 (0.5)
Surgical department	
Traumatology	237 (54.5)
General surgery	106 (24.4)
Oral and maxillofacial surgery	92 (21.1)
Most frequent types of surgery	
Traumatology	
Osteotomy	50 (21.2)
Arthroscopy	42 (17.7)
Tendons, muscles of the hands	38 (16.0)
Metal removal	25 (10.5)
Others	82 (34.6)
General surgery	
Cholecystectomy	37 (34.9)
Thyroidectomy	23 (21.7)
Gastrointestinal surgery	22 (20.8)
Inguinal hernia repair	18 (17.0)
Others	6 (5.6)
Oral and maxillofacial surgery	
Osteotomy	60 (65.2)
Plastic surgery	17 (18.5)
Debridement	15 (16.3)

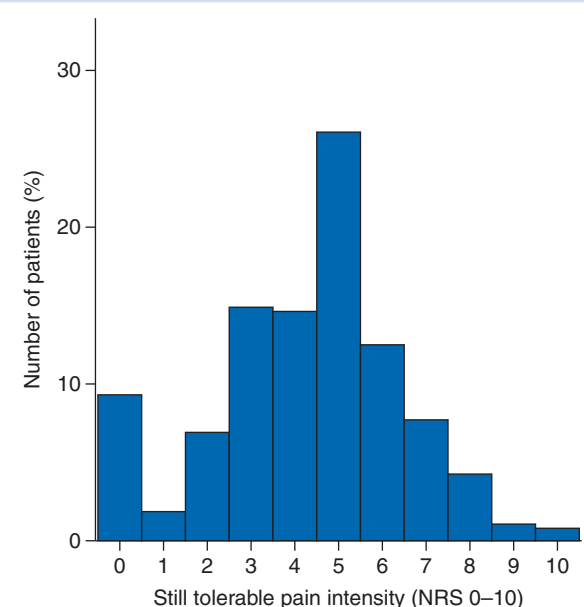


Fig 1 Distribution of estimated tolerable postoperative pain intensities (NRS 0–10) before operation of the entire study population (n=435).

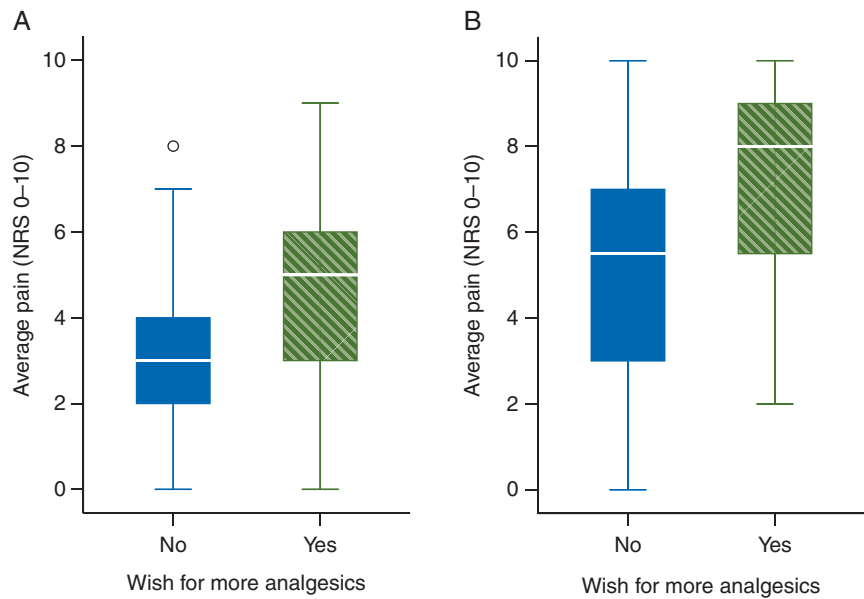


Fig 2 Differences in average and worst pain intensities among patients with and without the desire for more analgesics in the period from surgery to the first postoperative day.

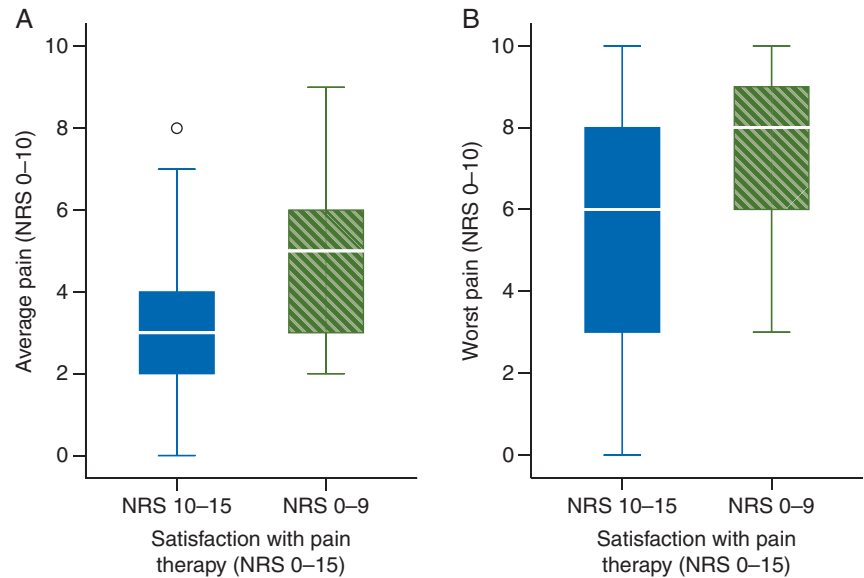


Fig 3 Average and worst pain intensities reported by patients very satisfied and satisfied with postoperative pain treatment (NRS 10–15) compared with those who are less satisfied (NRS 0–9).

for average and for worst pain intensity since surgery ($P \leq 0.001$).

Relation between pain intensity and pain-related interferences

Movement, sleep, and mood were adversely affected by pain with median scores on the NRS of 4.0, 3.0, and 2.0, all ranging from NRS 0 to 10. Deep breathing was not interfered

by pain in 53% of the patients resulting in a pain-related interference score of median NRS 0 (0–10). The total pain-related interference score for movement, deep breathing and coughing, sleep, and mood was median NRS 2.5 (0–10). The relations of average and worst pain intensities during the time since surgery and the four pain-related interferences and the total pain-related interference score are shown in Figure 4.

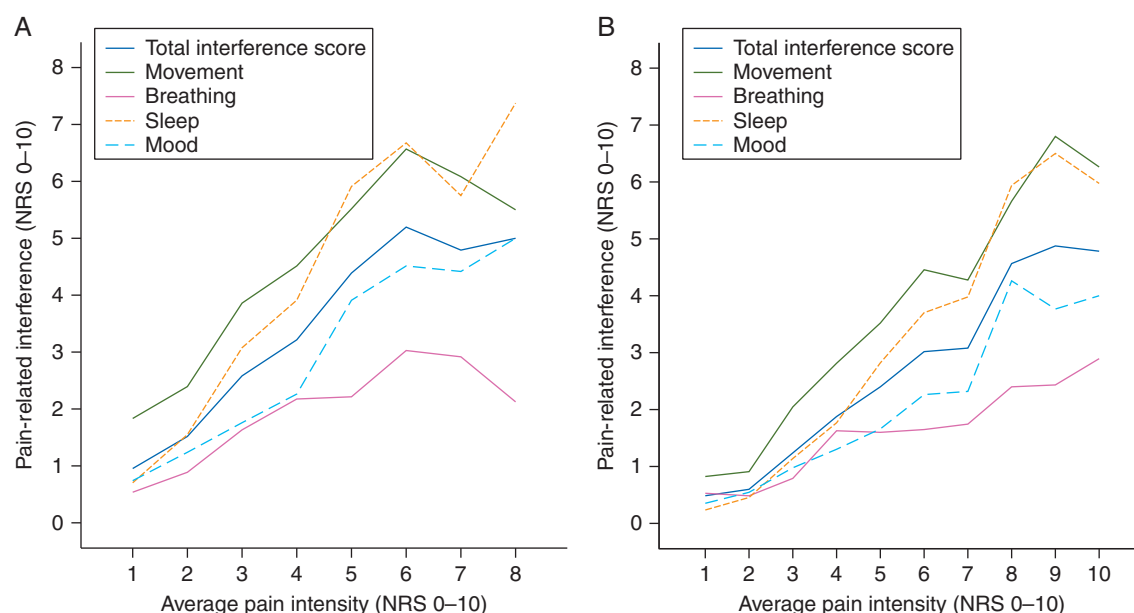


Fig 4 Relation between average and worst postoperative pain intensities (NRS 0–10) since surgery and pain-related interference. Pain-related interferences (NRS 0–10) are measured (i) during movement; (ii) when taking deep breaths or coughing; (iii) with sleep; and (iv) with mood. The mean of these four variables is shown as a total interference score.

Patients without pain were excluded from the cut-off analysis based on pain-related interference. A total of 25 patients reported an average pain intensity of NRS 0 leaving 410 patients for further analysis. The optimal CPs between mild and moderate, and moderate and severe pain were defined when they had the largest between-category *F* ratio using Pillai's trace, Wilks' λ , and Hotelling's statistic. The CPs for average pain during the first postoperative day were estimated to be 2/4 (NRS 1–2, mild; 3–4, moderate; 5–10, severe) (Fig. 5).

Twelve patients reported a worst pain intensity of NRS 0 and were excluded from this analysis, leaving a total of 423 patients. For worst pain intensity, the statistical analysis showed higher CPs of 4/7 (NRS 1–4, mild; 5–7, moderate; 8–10, severe) (Fig. 5).

The estimated score for postoperative tolerable pain intensity before operation was NRS 4.0. The comparison of average postoperative pain in patients who did not wish for more analgesia after surgery and those who would have liked more postoperative analgesia yielded median values of NRS 3.0 (0–8) vs 5.0 (0–9). The comparison of average postoperative pain for patients satisfied or not satisfied with pain treatment had a median of average pain since surgery also yielded median values of NRS 3.0 (0–8) vs 5.0 (2–9). This implies that the optimal cut-off is best described at \geq NRS 4. However, the relation between pain intensity and pain-related interference gave a CP at \geq NRS 3.

With three out of the four applied methods identifying $\text{NRS} \geq 4$ as the CP, we defined the latter as the optimal CP. A comparison of estimated tolerable pain intensity before operation between patients with mild ($\text{NRS} < 4$) and

moderate-to-severe pain ($\text{NRS} \geq 4$) demonstrated no differences ($P=0.826$). Thus, a different interpretation of the NRS between patients with mild and moderate-to-severe pain as a possible confounder can be excluded.

Discussion

In this study, we sought to determine the optimal CP between mild and moderate-to-severe postoperative pain at the first day after surgery. Moderate pain was considered in this study as pain requiring analgesic intervention and leading to relevant pain-related interference with movement, sleep, mood, and deep breaths. The optimal CP for average pain between mild and moderate intensity was $\text{NRS} \geq 4$ indicated by three of the four applied methods.

In acute postoperative pain, CPs are widely used as a basis for administering or withholding opioid analgesics, but no consensus exists as to appropriate treatment thresholds. Consequently, various arbitrarily chosen CPs are used in clinical protocols and research. It is generally agreed that CPs only serve as a guideline. Pain treatment should be tailored to individual needs. However, an inappropriate CP on a pain treatment protocol may carry a risk of over- or undertreatment.

CPs are used in various study designs. In clinical trials, the aim of treatment may be the reduction of pain below a defined CP. In such instances, predefined doses of analgesics are titrated until the CP is arrived at. This is usually done by selecting an NRS or VAS CP.^{4 7 9 14 15} CPs are also used in aetiologic^{5 16} and prognostic studies. In such studies,

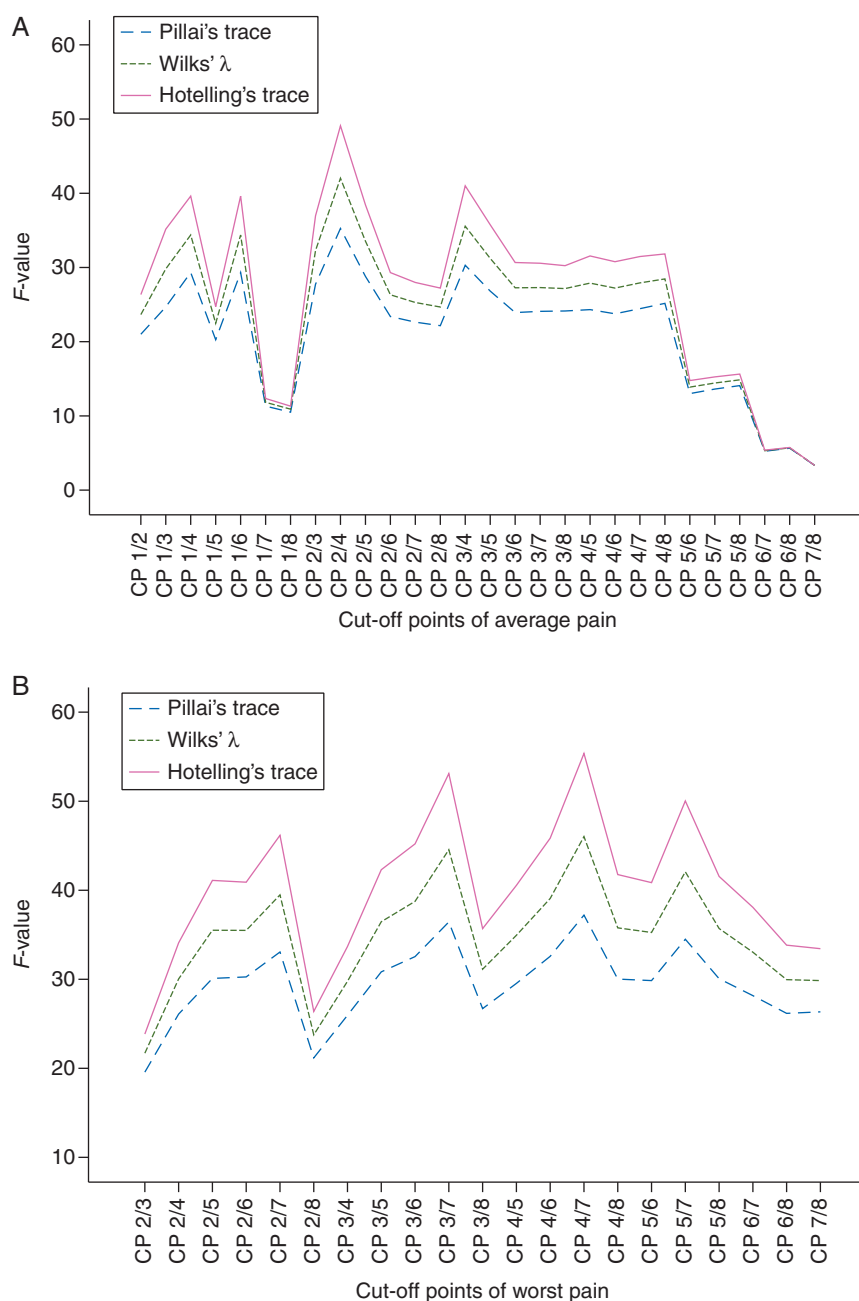


Fig 5 Average and worst pain intensities were each divided into three groups defined by their CPs. CP 4/6 stands for NRS 1–4, mild; NRS 5–6, moderate; and NRS 7–10, severe pain. For each CP, multivariate analyses were used with different methods (Pillai's trace, Wilks' λ , and Hotelling's trace) to calculate the best relation of each CP with the average of four pain-related interferences (movement, deep breathing, sleep, and mood). The highest *F*-values indicate the most significant relationship between pain interference and the corresponding CPs.

factors are determined which predict the incidence of pain above a certain CP.^{17 18}

There is no agreement on the optimal CP for pain treatment and there is no agreement on how to identify an optimal CP on the NRS for postoperative pain. To maximize validity of our analysed optimal CP, we compared several distinct outcome measures. Four methods were adopted to characterize the optimal NRS CP. These were, 'tolerable

pain intensity', 'patient's wish for more analgesic', 'satisfaction with pain therapy', and 'pain-related interference with movement, sleep, mood, and deep breaths'.

Three of the four methods identified a CP of NRS ≥ 4 as optimal. First, the preoperative evaluation of a tolerable postoperative pain threshold identified a CP of NRS 4.0. Secondly, the CP of NRS ≥ 4 lay between the median pain intensities of patients without further analgesic demands and those who

would prefer to have received additional pain medication. Thirdly, pain intensity between patient groups very satisfied or satisfied compared with those less satisfied with pain therapy gave similar results. Fourthly, the relation between average pain intensity since surgery and pain-related interference with movement, sleep, mood, and deep breaths resulted in a lower threshold of $\text{NRS} \geq 3$.

Previously, two methods have been used to identify CPs for postoperative pain. The first method, an exclusive matching of VAS or NRS pain scores with the terms mild, moderate, and severe of the VRS, did not yield consistent results.⁹ A relationship between patients' verbal rating of moderate pain and need for analgesic treatment is often postulated⁹ but has not been proven. One large prospective study asked patients with acute pain about the acceptability of their pain.¹¹ Thirty-one per cent of patients who reported severe pain on a VRS (mild, moderate, severe pain) rated their pain as acceptable.¹¹

A second established method to identify CPs relates pain intensity to the extent of pain-related interference with activity, sleep, and mood.¹² In our study, this method gave rise to a lower CP of $\text{NRS} \geq 3$ when compared with a value of $\text{NRS} \geq 4$ given by the other three methods. The method was primarily developed for cancer pain and its use may not be satisfactory in the acute postoperative situation. Transferring CP derivation methods from chronic pain syndromes to acute postoperative pain conditions should be undertaken with caution.¹² The nature of chronic pain may result in different pain-related interferences¹⁹ when compared with acute postoperative pain. Furthermore, therapeutic aims differ in acute and chronic pain therapy. Chronic pain therapy tries to improve physical and mental functioning, that is, health-related quality of life. Thus, reduction of chronic pain intensity is not the only objective. Acute postoperative pain therapy primarily focuses on pain intensity reduction. This pain reduction allows for improved physical and mental functioning.

In our study population, a cut-off for average pain intensity since surgery based on patients very satisfied or satisfied with pain treatment was identified as $\text{NRS} \geq 4$. This cut-off value is consistent with a recent multicentre study including some 2200 patients.²⁰ Patients rating their pain treatment as very good or good on a six-item scale scored their pain intensities at rest as NRS 3 or lower. Higher pain intensities ($\text{NRS} \geq 4$) were associated with poorer satisfaction scores.

As in other pain studies, our results showed a large range of pain intensities experienced acceptable to patients.⁹ This indicates that CPs do not identify sharp changeover points. They describe a most optimal threshold, only. Consequently, pain thresholds alone should not be used separately as a quality outcome variable as has been done by some authors and authorities.¹⁶ Furthermore, categorization of mild, moderate, and severe pain is reserved for treatment or study protocols and should never be used for therapeutic strategies in individual patients. The patient's perception of pain intensity and need for therapeutic intervention are extremely variable.^{11 15} In patient care, a strict adherence

to treatment protocols and 'absolute' VAS or NRS thresholds distract health personnel from administering individualized pain treatment.

Further limitations of CPs use in research studies include loss of statistical power and a risk of oversimplification when relating to other outcome or predictor variables.²¹ It is important to notice that there are many published studies in which patients were inappropriately categorized by CP. It has to be doubted that any additional knowledge is gained from arbitrarily selected groupings as long as there is no consensus on the classification of mild, moderate, and severe pain.²²

Two studies have previously analysed CPs in the postoperative period with regard to pain interference. Pain interference was measured using the modified BPI that analyses interferences with activity, walking, mood, sleep, and relation with others. One study examined pain intensities and pain-related interferences (5 items) in 77 patients after hip- or knee-replacement surgery.²² The authors obtained the optimal CPs for average pain at CP 4/5 (our scores: CP 2/4) and for worst pain at CP 4/7 (same scores as in our study). The other study calculated pain CPs after coronary artery bypass graft (CABG) surgery.²³ The authors analysed worst pain only during an 11-day period.²³ The CP 4/6 was optimal for five of the 11 assessment days and CPs 3/6 and 3/7 were optimal for three assessment days each.

There are several potential explanations for the discrepancies between our results and those of the two other postoperative CP studies. In contrast to our study, selected types of cardiac or orthopaedic surgery were analysed. This does lead to differences in pain-related interferences, for example, with regard to mobility. Mendoza and colleagues²³ analysed only 'worst pain intensity' and only four possible CPs (3/6; 3/7; 4/6; 4/7) after sternotomy. The study of orthopaedic surgery examined eight CP combinations only, ranging from 3/5 to 5/8, actually not covering our identified CPs for average pain of 2/4. Our study is to our knowledge the first to examine CPs for pain intensities in relation to pain-related interference during the first 24 h after surgery. In the studies discussed above, patients undergoing CABG were followed-up from postoperative days 4 to 14 and the orthopaedic patients were studied on postoperative day 3.

More recently, several study groups have used multivariate analyses to study the relationship between pain intensity and pain-related interference in chronic pain patients, including patients suffering from osteoarthritis pain,²⁴ back pain,²⁵ diabetic polyneuropathy,²⁶ amputation pain,²⁷ and pain after spinal cord injury.²⁸ In the majority of studies, $\text{NRS} \geq 4$ was reported to be the threshold for moderate pain in chronic pain patients, although CPs of ≥ 3 and ≥ 5 were also quoted.

A limitation of our study is that the wish for more analgesics during the time since surgery could have been influenced by a patient's general refusal of medication, fear of side-effects, or fear of addiction. We did not analyse these factors.

In conclusion, the present study identified a threshold of $\text{NRS} \geq 4$ between mild and moderate-to-severe pain of postoperative average pain intensity during the first 24 h after

surgery. This value was ascertained by means of four different methodological approaches. Three of these approaches arrived at the CP of $\text{NRS} \geq 4$.

Conflict of interest

None declared.

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