Anesthesiology 2009; 111:657–77

Predictors of Postoperative Pain and Analgesic Consumption

A Qualitative Systematic Review

Hui Yun Vivian Ip, M.B.Ch.B., M.R.C.P., F.R.C.A., Amir Abrishami, M.D.,† Philip W. H. Peng, M.B.B.S., F.R.C.P.C.,‡ Jean Wong, M.D., F.R.C.P.C.,§ Frances Chung, M.D., F.R.C.P.C.‖*

Pain is a subjective and multidimensional experience that is often inadequately managed in clinical practice. Effective control of postoperative pain is important after anesthesia and surgery. A systematic review was conducted to identify the independent predictive factors for postoperative pain and analgesic consumption. The authors identified 48 eligible studies with 23,037 patients included in the final analysis. Preoperative pain, anxiety, age, and type of surgery were four significant predictors for postoperative pain. Type of surgery, age, and psychological distress were the significant predictors for analgesic consumption. Gender was not found to be a consistent predictor as traditionally believed. Early identification of the predictors in patients at risk of postoperative pain will allow more effective intervention and better management. The coefficient of determination of the predictive models was less than 54%. More vigorous studies with robust statistics and validated designs are needed to investigate this field of interest.

PAIN is a multifaceted and highly personal experience, as McCaffery described "pain is whatever the experiencing person says it is and exists whenever he/she says it does".[1] It causes significant distress to patients and has adverse effects on the endocrine and immune function,[2] which can affect wound healing[3] and cardiopulmonary and thromboembolic diseases.[4–6]

Given that postoperative pain is one of the most frequently reported postoperative symptoms,[7] identification of the predictive factors for postoperative pain would facilitate early intervention and better pain management if the predictive factors for postoperative pain can be identified. To date, a review of the published literature indicates that there is no systematic review in this area. The purpose of this systematic review was to identify preoperative predictive factors for acute postoperative pain and analgesic consumption.

Materials and Methods

The purpose of the systematic review was to identify the risk factors determined by multivariate analyses for postoperative pain and analgesic consumption. We carried out separate analyses for pain intensity and analgesic consumption because these are two independent variables, with pain intensity being a subjective experience and analgesic consumption, which is also influenced by pharmacokinetics, together with health beliefs.

Search Strategy

We searched the databases MEDLINE (January 1950 to October 2008), EMBASE (January 1980 to October 2008), CINAHL (January 1982 to October 2008), Psychological Abstracts (PsycINFO 1806–2008) for all studies investigating the risk factors for acute postoperative pain using both univariate and multivariate analyses. The following search terms used were: "pain, postoperative," "pain: after surgery," "pain: follow:operation," "incision pain," "analgesic follow surgery," "risk factors," "risk assessment," "predict," "univariate analysis," "multivariate analysis," "regression analysis," "regression model," "logistic regression," "diagnostic model," "analysis of variance." The search was limited to adults over the age of 17 and to English language publications. The search strategy (see appendix) yielded 5,357 abstracts for initial consideration. All records were converted into the Reference Manager database. In addition, we hand-searched the reference lists of the relevant literature to identify additional references. Studies that were not in the public domain were not sought. Studies generated by the search were checked for relevance. Potentially relevant papers were retrieved in full and assessed by two independent reviewers (Drs. Ip and Abrishami) to minimize the risk of introducing bias to the results reviewed. Disagreements between the authors were resolved by the third reviewer (Dr. Chung).

Inclusion Criteria

This review was limited to publications in English, and retrospective studies were not included due to potential bias. Our inclusion population was the adult population of age 18 yr or above. Any study identifying one or more potential risk factors or predictive factors for acute postoperative pain or analgesic requirement was included. The potential risk factor or predictive factor had to be identified preoperatively. The postoperative period was defined as the period between arrival of the patient in recovery to 7 days after surgery, with day 1 being 24 h after surgery. Postoperative pain was measured *via* continuous scale of pain intensity or by categorical definition of moderate to severe pain. Also, pain had to be

* Clinical Fellow, † Research Fellow, ‡ Associate Professor, § Assistant Professor, ‖ Professor, Department of Anesthesiology, Toronto Western Hospital, University Health Network, University of Toronto, Toronto, Ontario, Canada.

Received from the Department of Anesthesia, Toronto Western Hospital, University Health Network, University of Toronto and University Health Network Foundation, Toronto, Ontario, Canada. Submitted for publication January 7, 2009. Accepted for publication April 8, 2009. Support was provided solely from institutional and/or departmental sources.

Mark A. Warner, M.D., served as Handling Editor for this article.

Address correspondence to Dr. Chung: Department of Anesthesiology, Toronto Western Hospital, University Health Network, University of Toronto, 399 Bathurst Street, McL 2-405, Toronto, Ontario M5T 2S8. frances.chung@uhn.on.ca.

Table 1. Quality Assessment Checklist

Sampling
Does sampling strictly outline inclusion/exclusion criteria?*
Was the stage when preoperative assessments were applied clearly stated?
Does the study define cutoff point for pain/severe pain/need for analgesia consumption?
Were the preoperative baseline pain scores measured and reported?
Was the sample described for important characteristics?
Predictive factors
Were clearly defined constructs of what were measured provided?
Does the study use standardized, psychometrically sound instruments for all measures?
Does the selection of predictive factors recognized the multifactorial interactions?
Analysis
Were multivariable techniques used to adjust for all potential confounders?
Were predictors clearly listed?
Was multicollinearity avoided?
Was overfitting of the data avoided?
Was prospective validation in homogenous cohorts carried out?
Follow-up
Was an appropriate time course chosen (too short a time course may not produce representative risk factors)?
Were the data complete for at least 80% of the sample measured at baseline?
If interview methods were used, were preoperative measurements blinded from postoperative measurements?
Were interviewers blinded from study objectives?
Were interviewers trained?

* Each question can be scored as yes, no, or unclear.

clearly measured and defined. All studies reporting multivariate analyses were included. Statistical importance of predictors was expressed as *P* value, regression coefficient, or odds ratio.

In this systematic review, surgeries performed under local anesthetics were excluded. This resulted from the fact that surgeries performed under local anesthetics tended to be less painful, the patient's experience intraoperatively and postoperatively would be different, together with the analgesic consumption. For those studies, only reporting univariate analysis was excluded because of the possible introduction of confounding factors. In addition, studies with risk factors found incidentally or those studies examining the pain intensity, analgesic consumption, or recovery were excluded. Only studies with original data were included. Also, review articles were excluded, but the bibliographies of the review articles were searched for additional references.

Quality Assessment of the Studies

Two independent reviewers (Drs. Ip and Abrishami) assessed quality by using the criteria shown in table 1, and any disagreements were resolved by discussion. If a resolution could not be reached, the opinion of the third reviewer was sought. The guideline for appraising the studies was adopted from systematic reviews on predictors and prognosis.[8–11] The assessment was based on four categories: sampling technique, predictive factors, statistical analysis, and follow-up (table 1). We did not adopt a scoring system like some systematic reviews[9–11] because it is not necessarily a scientific approach.[8] We evaluated each of the categories separately in every study. Each category was composed of different questions that could be answered as "Yes," "No," or "Unclear." If all the questions in the category were answered as "Yes," the category was considered as fully met. If the category had more than half the questions answered as "Yes," the study was considered as partly met, and if less than half of the questions were answered as "Yes," the category was considered as unsure. Finally, the category was considered as not met if all the related questions were answered as "No." The final conclusion was presented on the basis of studies with low risk for bias associated with each quality category of the quality assessment.[8] Therefore, studies with not met in any of the quality assessment categories were excluded when drawing conclusions (tables 2 and 3).[8]

Data Extraction, Data Analysis, and Conclusion Synthesis

Data extraction was performed by two reviewers (Drs. Ip and Abrishami). The following data were extracted from the study: sample size, type of surgery, study design, time course, measures of predictive factors, outcome measures (*i.e.*, postoperative pain score or analgesic consumption), statistical methods, number of predictor variables, coefficient of regression (B) and its standard error (SE). Data were verified for consistency and accuracy by the second author (Dr. Abrishami). Meta-analysis of the regression coefficients was carried out only for gender and anxiety factors because they are adequately reported among the studies in a consistent way. The analysis was done with MIX version 1.0 (Leon Bax, Kitasato Clinical Research Center, Kanagawa, Japan[12,13]), a meta-analysis software, by using a random-effect model with weighting according to the inverse of SE of the coefficients for each factor.[14] The I^2 statistic was used to measure inconsistency among the study results. $I^2 = [(Q - \mathrm{df})/Q] \times 100\%$, where Q is the χ^2 statistic and df is its degrees of freedom.[15] A value greater than 50% may be considered substantial heterogeneity. The range of regression coefficients was also reported in the text of the review for the above-mentioned factors. For age and type of surgery, the range of regression coefficient was not presented in the review, nor was a meta-analysis performed because these factors were defined or treated differently among the studies. For example, age was entered into the regression models in different ways (*e.g.*, age groups, continuous data, or categorical data) and type of surgery had different reference procedure (*e.g.*, gynecology, or ophthalmology,

Table 2. Predictive Factors for Postoperative Pain

Predictive factors for postoperative pain	Mixed surgical population								Gastrointestinal surgeries								Obstetrics & Gynecology surgeries												Others				Summary			
Study / Variables	*Aubrun 2008* [117]	*Gagliese 2008* [45]	*Mamie 2004* [33]	*Pavlin 2002* [118]	*Kalkman 2003*[30]	*Chia 2002* [26]	*Chung 1997* [27]	*Capeda 2003* [19]	*DeCosmo 2008*[29]	*Bisgaard 2001*[47]	*Taenzer 1986* [46]	*Scott 1983* [53]	*Boeke 1991* [25]	*Granot 2005* [52]	*Lau 2004* [49]	*Caumo 2002* [48]	*Rudin 2008* [23]	*Cohen 2005* [28]	*Kain 2000* [55]	*Hsu 2005* [54]	*Strulov 2007* [63]	*Keogh 2006* [32]	*Pan 2006* [22]	*Granot 2003* [65]	*Pud 2005* [56]	*Munafo 2003* [50]	*Healey 1998* [20]	*Fraser 1989* [119]	*Katz 2005* [31]	*Ozalp 2003* [60]	*Roth 2007* [62]	*Bachiocco 1990*[58]	No. of studies on this factors	Any correlation		No correlation
Sample size	N= 342	N= 246	N=304	N=175	N=1416	N=2298	N=10008	N=700	N=82	N=150	N=40	N=48	N=111	N=38	N=509	N=346	N=59	N=122	N=53	N=40	N=47	N=65	N=34	N=58	N=40	N=47	N=51	N=54	N=114	N=99	N=68	N=126		+	−	
I- Demographic factors																																				
Age		−	0		−	0	−		0	−					−	−	0									0	+						12	1	6	5
Female		+	0		0	−		+	+						+	0																	8	4	1	3
ASA							0									+																	2	1	0	1
Body mass index						0	+																										2	1	0	1
Level of education						0					−					0																	3	0	1	2
Parity																											+						1	1	0	0
II- Psychological factors																																				
Anxiety																																	15	15	0	0
- Anxiety trait											+					+				+						+							4	4	0	0
- Preop anxiety state					+				+			+	+	+				+		+	+				+				+			+	11	11	0	0
- Fear of postop pain			+																														1	1	0	0
Coping																																	6	3	1	2
- Self distraction																		+															1	1	0	0
- Information seeking behavior					−																												1	0	1	0
- Pain catastrophizing														+							+										0		3	2	0	1
- Coping style (general)											0																						1	0	0	1
Psychological distress																																	9	7	0	3
- Depressed mood/negative affect									+		+					+		0												+	0		6	4	0	2
- Psychological well-being																		0															1	0	0	1
- Personality*										+	+																					+	3	3	0	0
- Chronic sleeping difficulties			+																														1	1	0	0
- Preoperative diazepam																0																	1	0	0	1

(*continued*)

* Includes extroverted hostility, personality adjustment, neuroticism, psychoasthenia, aggressivity, hysteria. † Includes suprathreshold pain stimulation, heat pain perception, back pain threshold, cold presser pain, pressure algometry, etc.

ASA = American Society of Anesthesiologists status; PCA = patient-controlled analgesia; Postop = postoperative; Preop = preoperative.

Table 2. Continued

III- Preoperative pain																																				
Preoperative pain/analgesic experience																																	12	8	1	4
- Preoperative pain					+					+		0				+	+										–		0		0		8	4	1	3
- Chronic pain											+					+																	2	2	0	0
- History of pain in family			+																														1	0	0	0
- Preoperative analgesics	+															0																	2	1	0	1
- Previous surgery with PCA		+																															1	1	0	0
Preoperative pain perception																																	4	3	1	1
- Preoperative expectation of pain			+																				+										2	2	0	0
- Perception of pain control																						0											1	0	0	1
- Perception of analgesic control																						–											1	0	1	0
- Bias towards using analgesics											+																						1	1	0	0
Preoperative pain threshold†										–							–			–	–		–	–									6	0	6	0
IV- Surgical factors																																				
Type of surgery			0	+	+	+	+																										6	4	0	2
Surgery for cancer																–																	1	0	1	0
Incision size					0																												1	0	0	0
Duration of surgery							+									0																	2	1	0	1
Intraoperative opioid dose																0																	1	0	0	1
Information about surgery												0				0																	2	0	0	2
Previous surgery												+				0																	2	1	0	1

etc.) among the studies. The regression coefficients of other factors were not adequately reported in the included studies. To draw conclusions for each variable, we considered the following issues: a variable was considered to have significant correlation with postoperative pain outcomes if the respective statistical significance was $P < 0.05$. Also, the statistical power of each study with multiple regression was assessed by calculating the probability of type II error (β) using the number of variables, and total sample size (F test, multiple regression, G* power version 3.0.10; Franz Faul, Universitat Kiet, Germany). The effect size for power analysis is calculated by the software based on the squared multiple correlation (R^2) of the regression model. To minimize type II error, the power of a regression analysis is considered to be sufficient if it is at least 0.9.[16,17] Therefore, studies with statistical power less than 0.9 were considered statistically insufficient to show that there is no correlation between a variable and the study outcomes.

Results

Literature Search and Study Characteristics

The search strategy resulted in an initial yield of 5,357 references, of which 1,218 were duplicates. Therefore, a total of 4,139 references were generated by the electronic search. The title and abstracts were reviewed, and 111 articles were found to be of relevance. The full texts of 111 articles were retrieved and examined. Reference lists of relevant studies meeting inclusion criteria further identified eight articles not identified in the electronic search.[3,18–24] We excluded 71 articles as explained in figure 1. Finally, 48 articles were analyzed in this systematic review. This included a total of 23,037 patients.

The characteristics of all the studies are shown in table 4. The studies were heterogeneous in terms of sample size, type of surgery, variables examined, and instruments used for measuring variables. The three main groups of surgery with sufficient number of studies were mixed surgery, gastrointestinal, obstetrics, and gynecology surgery.

Methodological Quality of the Studies. The summary of the quality assessment of each study can be found in table 5. Only nine studies (18.7% of all the included studies) partially or fully met each category of the quality assessment.[25–33] The remaining studies had at least one category of the quality assessment considered as unsure. There were eight studies (16.6% of all the included studies) failing to meet at least one of categories of the quality assessment[34–41]; therefore, their findings were not included in drawing conclusions. Due to insufficient raw data from the included studies, it was not possible to perform the sensitivity analysis. The number of studies in each surgical group and their limitations in terms of the quality assessment are summarized in table 6. The most common limitation among all the

Table 3. Predictive Factors for Postoperative Analgesic Consumption

Predictive factors for postoperative analgesic use	Mixed surgical population						Gastrointestinal surgeries						Obstetrics & Gynecology						Others			Summary		
Study / Variables	*Aubrun 2002* [64]	*Chia 2002* [26]	*Chang 2006* [43]	*Dahmani 2001* [66]	*Gagliese 2008* [45]	*Cepeda 2003* [19]	*De Cosmo 2008* [29]	*Coulbault 2006* [44]	*Taenzer 1986* [46]	*Scott 1983* [53]	*Granot 2005* [52]	*Caumo 2002* [48]	*Katz 2008* [57]	*Cohen 2005* [28]	*Jamison 1993* [59]	*Hsu 2005* [54]	*Pan 2006* [22]	*Fraser 1989* [119]	*Aubrun 2003* [42]	*Ozalp 2003* [60]	*Bachiocco 1996* [61]	No. of studies on this factors	Any correlation	No correlation
																							+	–	
Sample size	N=1050	N=2298	N=1753	N=149	N= 246	N=700	N=82	N=74	N=40	N=48	N=38	N=346	N=117	N=122	N=68	N=40	N=34	N=54	N=329	N=99	N=126				
I) Demographics																									
Age	0	0	–		–			–	–					–					–			8	6	0	2
Female		–	0			+			+													4	2	1	1
ASA					+																	1	1	0	0
Height			0																			1	0	0	1
Weight		0	+																			2	1	0	1
Level of education		0																			+	2	1	0	1
Caucasian				+																		1	1	0	0
II) Psychological factors																									
Anxiety																						8	4	0	4
- Anxiety trait									+													1	1	0	0
- Preoperative anxiety state							0			0	0		0		+		+			+		7	3	0	4
Coping																						3	2	0	1
- Emotional support														+								1	1	0	0
- Religious-based														+								1	1	0	0
- Intrusive thought/ avoidant behavior													+									1	1	0	0
- Pain catastrophizing											0											1	0	0	1
Psychological distress																						6	5	0	1
- Depressed mood/negative affect							+							0	+							3	2	0	1
- Personality*									+						+						+	3	3	0	0
- Preop psychotropic drugs								+														1	1	0	0
III) Preoperative pain																									
Preoperative pain/analgesic experience																						5	3	1	1
- Preoperative pain	+								+													2	2	0	0
- Preoperative analgesics																					–	1	0	1	0
- Previous surgery with PCA		0																				1	0	0	1
Preoperative expectation of pain															+							1	1	0	0
Pain threshold†																–	–					2	0	2	0
IV) Surgical factors																									
Type of surgery		0	+	+	+																	4	3	0	0
Surgery for cancer			+																			1	1	0	0
Duration of surgery				+	+																	2	2	0	0
Intra-operative opioid				0																		1	0	0	1
Information about surgery										+												1	1	0	0

* Includes extroversion, neuroticism, irritability, and paranoia. † Includes thermal pain threshold, fentanyl sensitivity (increase in the pressure pain tolerance after fentanyl administration).

ASA = American Society of Anesthesiologists status; PCA = patient-controlled analgesia; Preop = preoperative.

included studies was in the analysis category. This included factors such as insufficient measures to avoid collinearity, overfitting, and the lack of external validation of the models.

Predictors of Postoperative Pain Intensity and/or Analgesic Consumption. After identifying 8 poor quality studies, 32 and 21 studies evaluating the predictive factors of postoperative pain intensity (table 2) and an-

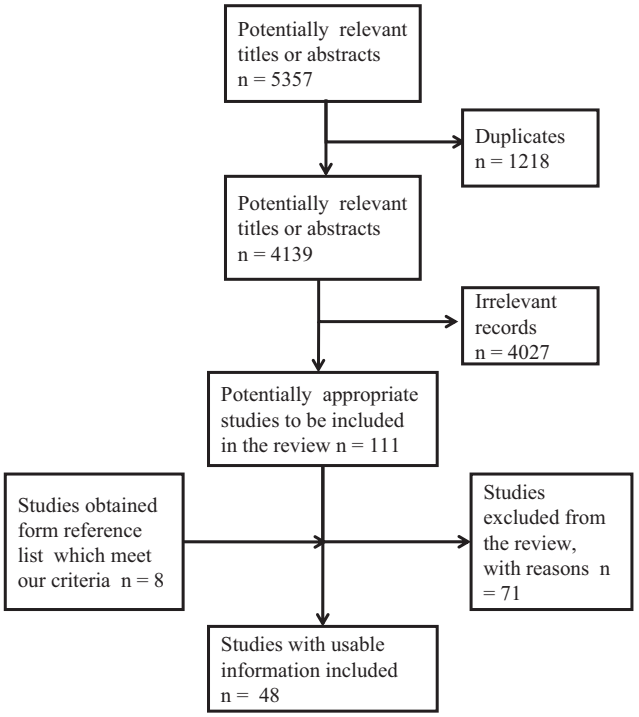

Fig. 1. Flow chart showing the process of article selection.

algesic consumption (table 3), respectively, were available for drawing conclusions. These factors can be classified into four major categories: demographics, psychological, preoperative pain, and surgery-related factors.

Demographics. Age was commonly found to have negative correlation with both analgesic consumption (six studies[28,42–46]) and postoperative pain intensity (six studies[27,30,45,47–49]); however, the latter finding was less consistent among the included studies (tables 2 and 3). The negative correlation suggested that the younger the patients, the more postoperative pain or analgesic requirement. There was one study that showed positive correlation between age and postoperative pain.[20] There were five studies[23,26,29,33,50] failing to show any correlation between age and postoperative pain (fig. 2). Of them, three studies[23,29,50] had a sample size ranging from 47 to 82 patients and low statistical power ($1 - \beta = 0.4 - 0.7$) which was relatively insufficient to detect an existing correlation between age and postoperative pain.

There were conflicting findings regarding correlation between gender and postoperative pain outcomes. Females patients were found to have more postoperative pain in four studies[19,29,45,49] (table 2) (coefficient of regression range: $0.22 - 0.79$) and less pain in one study[26] (coefficient of regression: -0.56). The pooled coefficient was 0.53 (95% CI 0.44–0.63; $P < 0.001$, $I^2 = 93.6\%$). Two studies showed positive correlation,[19,46] and one showed negative correlation[26] between female gender and postoperative analgesic consumption (fig. 3). On the other hand, three studies failed to show a significant correlation between gender and postoperative pain[30,33,48] and one between gender and analgesia requirement[51] (figs. 2 and 3). They all had high statistical power ($1 - \beta > 0.9$). Other demographic factors, *e.g.*, body mass, weight, American Society of Anesthesiologists status, and education level were evaluated in only a few studies and were found to be related to postoperative pain and/or analgesic consumption only in isolated studies (figs. 2 and 3).

Psychological Factors. These factors can be divided into three subcategories: anxiety, psychological distress, and coping strategies:

Anxiety was the most common predictor for postoperative pain and was shown to have positive correlation with pain intensity in 15 studies (table 2). Of these, six studies were on gastrointestinal surgery,[25,29,46,48,52,53] five on obstetrics and gynecology surgery,[23,50,54–56] two on mixed surgical population,[30,33] one on breast surgery,[57] and one on thoracic surgery.[58] Three studies specified state anxiety,[25,52,53] whereas three found trait anxiety to be significant.[46,48,50] The coefficient of regression (β) of preoperative anxiety state ranged from 0.05 to 1.60. The pooled coefficient regression was 0.074 (95% CI 0.042–0.106, $P < 0.001$, $I^2 = 87\%$); for instance, any change in preoperative anxiety score (*e.g.*, State-Trait Anxiety Inventory score) by 10 can increase the pain intensity score by 0.74. Anxiety was also found to have positive correlation with postoperative analgesic consumption in four studies.[22,46,59,60] This finding was not supported by another four studies but they all had insufficient statistical power ($1 - \beta = 0.5 - 0.7$).

Psychological distress (other than anxiety) mainly measured by evaluating the patient's mood, affect or personality trait (*e.g.*, neuroticism, hostility, *etc.*) was found to have positive correlation with both postoperative pain[29,33,46–48,58,60] and analgesic consumption[29,44,46,59,61] (figs. 2 and 3). The regression coefficients were not adequately reported to carry out meta-analysis. On the other hand, three studies failed to show any significant relation between psychological distress and pain[28,48,62] and/or analgesic consumption.[28] Of these, only one study had a relatively large sample size of 346 patients and an appropriate statistical power ($1 - \beta > 0.9$). It showed no relation between preoperative diazepam use and postoperative pain intensity[28] (table 2).

Coping strategies were found to predict the intensity of postoperative pain[28,30,52,63] and the amount of postoperative analgesic requirement.[28,57] Self-distraction and pain catastrophizing were correlated with higher postoperative pain scores in three studies[28,52,63] and information seeking behavior with less pain.[30] Coping strategies such as emotional support, religious-based, or

Table 4. Characteristics of All Studies

Mixed surgical groups

Study	n	Type of Surgery	VAS/Qu	Time course	Outcome Measures
Aubrun 2008[117]	342	Minor (urology, gynecology, TURP, osteosynthesis material remove); moderate (intervertebral disc surgery, inguinal repair, thyroidectomy, hip replacement, appendicectomy); major (spinal surgery, knee arthroplasty, shoulder surgery, laparoscopic/bowel surgery, renal surgery)	Preoperative pain VAS, analgesic used, preop anxiety level numerical rating scale (NRSa)	Post anesthetics care unit	Severe pain with VAS or NRS ≥ 70
Gagliese 2008 [45]	246	Gynecology/urological, gastrointestinal, orthopedic surgery	McGills pain qu, Numeric rating scale	24h postop pain score and cumulative morphine	Pain intensity and cumulative IV morphine PCA intake for young (≤60 yr) and old (> 60 yr) age groups
Bandyopadhyay 2007 [34]	315	Women undergone day surgery: dilation and curettage, breast biopsy, termination of pregnancy	Likert scale for pain if pain within 48hr of d/c, management of pain at home	Immediately following d/c, 48 hr post d/c	Pain intensity
Chang 2006 [43]	1753	Chest, upper abdominal and lower extremities requiring PCEA	Demographic details, verbal pain score, total dose delivered from PCEA	Daily for 3 days	Total patient-controlled epidural analgesia (inadequate analgesia when verbal pain score ≥ 5)
Mamie 2004 [33]	304	Intraperitoneal or orthopedic	Qu: Preop: social and psychological factors, previous history of pain, pt knowledge of pain, medical and surgical characteristics; postop: VAS (intensity of pain at rest and pain during mobilization for orthopedic or coughing for intraperitoneal sx)	Preop psychosocial qu, within 24hr postop on each of the following 2 days (once a day)	Severe pain VAS > 5 and moderate pain ≤ 5
Cepeda 2003 [19]	700	Hospitalized or ambulatory surgery GA (pt w NRS 5 or more), head and neck, thoracic, abdominal, orthopedics spinal	Numeric rating scale and degree of pain improvement on 5-pt Likert scale	Until pain intensity <=4 of 10	Pain intensity (NRS), opioid requirement until pain intensity measured by NRS ≤ 4 of 10
Kalkman 2003 [30]	1416	Opthalmic, ENT, laparoscopic, orthopedic, abdominal	NRS - numerical rating score for pain, severity of preop pain in terms of quality of life qu short form 36, STAI, anxiety and information scale (APAIS-5pt Likert scale), preop anxiety score, score for pt's need for information regarding scheduled surgery and anesthesia	every 15min until d/c	Presence of severe pain defined as NRS≥8, occurring at least once within the first hour after arrival at the PACU
Aubrun 2002 [64]	1050	Ortho, urologic, abdominal, gynecology, vascular, thoracic, max-fax	VAS, % pt with pain relief	Recovery	Patients were divided into 2 groups according to age: young and elderly (age ≥70 yr). VAS and percentage of patient with pain relief with analgesia (VAS score of ≤30mm)
Pavlin 2002 [118]	175	Ambulatory: knee arthroscopy, hernia repair, pelvic laparoscopy, TV uterine surgery, surgery for breast disease, plastic surgery	Numeric pain score (0-10), duration of pain score >3	every 15 min until d/c	Pain intensity
Chia 2002 [26]	2298	Outpatient surgery under GA	Demographic details, Op sites, VASR (visual analogue scale at rest), VASM (visual analogue scale on movement), morphine consumption	Preop, 8am and 10am daily for 3 postop days	Morphine consumption where VAS at rest of 3 was considered satisfactory with regard to the effectiveness of pain relief, VAS on movement and at rest

(*continued*)

Table 4. Continued

Dahmani 2001 [66]	149	Ortho, general, urology, gynecology, ENT under GA	Verbal score (pain)	In recovery (Pt only d/c when VS < or =1)	Morphine requirements
Thomas 1998 [37]	91	Ortho: hip replacement, knee replacement, spinal nerve root decompression surgery	McGill Pain Qu, VAS, Likert scales (states and beliefs, *e.g.*, anxiety about pain/outcome of op), total opiate dose, interview: nurses' assessment of pt pain and pain experience better/worse than expected, satisfaction with pain management	D1-5 postop, d/c, 1 month	Pain severity (PPI, 2-5/0-1)
Chung 1997 [27]	10008	Ambulatory Surgery: orthopedic; urology; general; plastics; neurology; ENT; gynecology; ophthalmology	PACU and ASU: Aldrete score; PADS; standardized pain check-off form; telephone interview postop to classify pain as none, mild, moderate, severe	24h postop	With or without severe pain (categorical scale)
Puntillo 1994 [36]	74	Abdominal vascular, coronary artery bypass graft	NRS - numerical rating score for pain, McGill Pain Qu short form (sensory and affective pain), California Q set (personality adjustment)	3 consecutive postop days during first 5 days in ICU or until transferred. 78% patients entered on postop day 1, 97% entered on postop day 2	Pain intensity
Voulgari 1991 [40]	162	Abdominal + others	Eysenck personality qu, Foulds' Hostility Qu (Personality), life events inventory, Zung's anxiety and Depression scales, VAS, semistructured interview conducted by anesth preop and Anesth + psychologist (psychological test EPQ, Fould Anxiety and depression on postoperative interview)	Afternoon prior to surgery, semistructured interview, 72h postop both psychologist and anesthetist repeated interviews for Zung anxiety and depression scales	Pain intensity and narcotic consumption

Gastrointestinal surgery

Study ID	n	Type of Surgery	VAS/Qu	Time course	Outcome Measures
De Cosmo 2008 [29]	82	Elective cholecystectomy	Pain: VAS at rest and on coughing; anxiety: Zung SAS; Depression: SRQ-D	Preop SAS (anxiety) and SRQ-D (for depression); post op VAS rest and coughing	Pain intensity
Coulbault 2006 [44]	74	Abdominal with colorectal or coloanal anastomosis	Anxiety with VAS; pain: VAS; cumulative 24 hr postop dose of morphine; pain in recovery: Verbal rating scale (0-4); DNA extracted from whole blood sample	Preop anxiety (0-10 on VAS); morphine titration / 5 min in recovery until <2 score; 24h morphine accumulation	Cumulative 24 hr postop dose of morphine
Granot 2005 [52]	38	Elective abdominal surgery (hernioplasty and cholecystectomy)	Qu: Pain catastrophizing scale (coping attempt), state-trait anxiety inventory (product of inadequate coping), VAS	VAS = 2 day postop morning, Catastrophizing level = 1 day preop:STAI = on the day of op	Pain intensity and analgesic consumption
Lau H 2004 [49]	509	Endoscopic totally extraperitoneal inguinal hernioplasty	Daily linear analogue pain score at rest and on coughing	Daily for 5 days postop	Pain intensity
Caumo 2002 [48]	346	Elective abdominal ASA I-III	VAS, STAI, Montgomer-Asberg depression rating scale	12, 24hr postop for pain	Moderate or intense pain (VAS > 30mm)
Bisgaard 2001 [47]	150	Laparoscopic cholecystectomy	Questionnaires regarding expectation of pain, psychometric scale for neuroticism, cold pressor time immersion, Verbal rating scale for incisional pain, intra -abdominal pain and shoulder pain, VAS	6hr postop and daily for 7 days postop	Pain intensity

(*continued*)

Table 4. Continued

Ure 1994 [39]	382	Laparoscopic cholecystectomy	VAS, 5-pt verbal rating scale, analgesic consumption	Day before op - preop pain qu ; 5hr post-op then 8am/6pm post op for first 3 postop days; if stay more than 3 days - interview on d/c; 2 wks postop	High intensity of pain (patients who need opioids or VAS > 50 any time postop or both, patients who required analgesics up to the 2nd postop day)
Boeke 1991 [25]	111	Elective cholecystectomy	Dutch version of STAI- State anxiety (A-state) scale for transient anxiety states 5 pt rating scale for pain	1 day before surgery, third day postop	Pain intensity
Weir 1990 [41]	248	Elective intra-abdominal Surgery	Demographic data, narcotics consumption	analgesia administered in recovery, amount and frequency of doses of narcotics administered in first 48hr	Analgesic doses given in first 48 hr
Taenzer 1986 [46]	40	Elective cholecystectomy	STAI/Beck depression inventory; Eysenck personality inventory, Rotter Locus of control scale, Health locus of control scale, Repressing sensitizing defensive style, Marlowe-Crowne scale for STAI-trait to explore defensive style and postop outcome; VAS and McGill Pain Qu; analgesia intake; gallbladder pain history interview; medication bias assessment (subject's attitude toward taking meds) and Wolfer-Davis Scale (perception of their preop physical status)	2 wk prior to surgery for: preop pain (Gallbladder pain history interview), (STAI, EPI, BDI, HLOC, SDS and MCS), day of Surgery for (STAI-State, BDI, W-D); Days 1-3 morning (VAS, MPQ) and afternoon (STAI-State, BDI), Day 6 (VAS MPQ, STAI-State, BDI)	Pain intensity and amount of narcotic analgesics administered
Scott 1983 [53]	48	Elective cholecystectomy	Qu-McGills Pain Qu; STAI; Fear of Surgery Qu (6 pt scale); Surgery Info Qu; Analgesics received upon request.	Qu afternoon preceding Surgery then 5 days postop	Pain intensity and analgesic administered

Obstetrics and gynecology surgery

Study ID	n	Type of surgery	VAS/Qu	Time course	Outcome measures
Katz 2008 [57]	117	Abdominal gynecology	IES, VAS	IES (1wk pre-op), VAS 3,6,12,24,48hr postop; anxiety and negative affect 24,48hr postop)	Cumulative number of PCA lockout interval demands and cumulative morphine consumption at 48 hr postop
Rudin 2008 [23]	59	Laparoscopic tubal ligation	Hospital anxiety and depression scale (HADS), STAI, Present Pain Index (PPI), Visual analogue scale (VAS), Short-form McGill Pain Qu, quantitative sensory testing	2 and 4h after surgery, in the evening day 0, twice the first postop day and once each evening until postop day 10.	Maximal VAS at rest, during walking or staircase climbing, and from supine to standing position. (had the incidence of patients with VAS > 70 but not as end-point)
Strulov 2007 [63]	47	Elective caesarean section under regional nerve block except 2 had general anesthetics	pain threshold, suprathreshold pain, Pain catastrophizing scale, VAS, analgesic consumption	Quantitative sensory testing, Pain catastrophizing scale 1 or 2 days preop, VAS recovery, day 1 and 2 postop, pain catastrophizing scale day 1 post op.	Pain intensity
Pan 2006 [22]	34	Elective caesarean section under subarachnoid anesthetics	preop 2 wks before CS-VAS for pain intensity and unpleasantness; STAI; audio sensitivity - mechanical VAS; thermal sensory analyzer; thermal pain threshold; suprathreshold thermal pain intensity - VAS	Recovery, first 6, 18 , 24h postop	Pain intensity at rest, evoked and overall, morphine equivalents require d for analgesia in recovery and 1st 6 hr of PCA on the ward
Keogh 2006 [32]	65	Elective caesarean section under regional block	Expectation of CS qu; Anxiety sensitivity index; Verbal analog scale (based on McGills pain qu), short-form McGill pain qu; Verbal rating fear index	Time 1: after recruitment at wk 36 and before operation at term; time 2: during CS; Time 3: following delivery while recovering on ward between 1-4 days postnatal	Pain intensity

(*continued*)

Table 4. Continued

Cohen 2005 [28]	122	Abdominal gynecology	Pain: McGills Pain Qu (PRIT and PPI); Negative affect (26-item stress scale); Brief COPE (coping tendency or style); Mental Health inventory scale (psych distress); Impact of events scale (cognitive responses to stressful events)	48hr postop and 4wks	Pain intensity and morphine consumption
Hsu 2005 [54]	40	Abdominal total hysterectomy and myomectomy	VAS; STAI; pain threshold and pain tolerance pressure: electronic pressure algometer	Preop anxiety before entered the OR, pain threshold: after patient transferred to OR, VAS: PACU and 24h postop	Pain intensity and morphine consumption
Pud 2005 [56]	40	Termination of pregnancy	STAI, VAS	1h preop - STAI, VAS – 15, 30, 60m postop	Mild pain (VAS 0-30) and moderate to severe pain (VAS 31-100)
Granot 2003 [65]	58	Elective caesarean section under regional block	Heat pain threshold: thermode applied to forearm and pt differ between painful heat sensation; suprathreshold pain:phasic heat stimuli and report level of perceived pain intensity and unpleasantness by VAS; pain by VAS	1 or 2 days pre op : heat pain threshold and suprathreshold pain; 1st day postop pain	Pain intensity
Munafo 2003 [50]	47	Elective minor gynecology (laparoscopy ± dye test, laparoscopic sterilization, hysteroscopy)	STAI, Short form McGills Pain Qu, intra-op analgesia consumption	1h preop - STAI; 3h postop McGills qu short form; next day - intraop analgesia	Pain intensity
Kain 2000 [55]	53	Abdominal hysterectomy for benign fibroid uterus	Qu-Trait & state anxiety, assess coping style, perceived stress scale, McGills pain qu, VAS, global health qu for pt recovery	immediate-1-2h postop, ward-12, 24, 48h postop, home- day 1, 2, 7	Pain intensity
Healey 1998 [20]	51	Laparoscopic gynecology	Symptoms diary: VAS for abdominal pain, pelvic pain, vaginal pain, shoulder pain, back pain, nausea, energy, abdominal bloating and others	Prior to surgery, 4, 12h, day 1 and 7 postop	Pain intensity
Thomas 1995 [38]	110	Elective abdominal hysterectomy	STAI, Eysenck's personality qu (neuroticism, Miller's behavioral style scale (coping style), short form McGills pain qu, analgesic consumption	Shortly after admission (preop) STAI, EPQ, Miller's behavior style scale, but did not state postop time	Pain intensity for 2 groups of postop patients: PCA or IM injections
Perry 1994 [35]	99	Abdominal hysterectomy with no known expected cancer	Control (general), control over analgesia, Trait anxiety, State anxiety (VAS), expectation of postop pain, McGills Pain Qu, VAS, Likert scale (comfort level), recovery parameters (time to oral intake and d/c)	Preop qu of control, anxiety and expectation; 1st postop day - McGill Pain Qu, VAS, Likert scale	Pain intensity, analgesic usage and requests for PCA-delivered medications
Jamison 1993 [59]	68	Abdominal hysterectomy	Pt and nurses qu-preop, day1 postop & day3 postop	3 days	IV-PCA dose/demand ratio and hourly analgesic usage
Fraser 1989 [119]	54	Tubal ligation	Krantz Health Opinion, STAI, McGills Pain Qu with pain rating index, number of words, present pain intensity, modified functional assessment instrument	Preop MPQ, MFAI, BSI, KHOS, STAI, 7 days postop	Pain intensity and amount of narcotic pain medication used

(*continued*)

Table 4. Continued

Breast surgery

Study ID	n	Type of Surgery	VAS/Qu	Time course	Outcome measures
Katz 2005 [31]	114	Breast Cancer Surgery	0-10 numerical rating scales, Qu: Beck Depression inventory, STAI, Hamilton depression and anxiety rating scales; disease-specific emotional functioning: Functional assessment of cancer treatment emotional scale, Somotosensory amplification scale, Illness behavior disease conviction scale	6.4 (average) days preop, 2,10 and 30 days postop via telephone interviews by doctoral level clinical psychologist or a nurse practitioner	Clinically meaningful acute pain (NRS ≥ 5)
Ozalp 2003 [60]	99	Radical mastectomy	Preop: STAI and beck depression inventory; postop: VAS, 5 pt scale satisfactory report	24hr postop	Pain intensity, total consumption , dose/demand ratio of morphine PCA

Orthopedic surgery

Study ID	n	Type of Surgery	VAS/Qu	Time course	Outcome measures
Roth 2007 [62]	68	Total knee arthroplasty	McGills Pain Qu, Pain catastrophizing scale, shortened version of profile of Mood States, Mini-mental state exam	Preop, postop day 1-3	Pain intensity
Aubrun 2003 [42]	329	Total hip replacement	VAS, dose of IV morphine postop in recovery, dose of SC morphine within 24h	Total IV morphine used in recovery, SC morphine use 24h postop	Dose of IV morphine during titration in PACU, dose of SC morphine administered

Thoracic surgery

Study ID	N	Type of surgery	VAS/Qu	Time course	Outcome measures
Bachiocco 1996 [61]	126	Thoracic surgery	Domain-linked qu; Minnesota multiphasic personality inventory, Eysenck Personality inventory; STAI; amount of analgesics consumed	Preop qu and patient completed personality tests, postop pain latency(time interval between awaking from anesthetics and onset of pain); intensity at 4pm; duration : no, of days pt reported pain	Analgesic request (Ketoprofene – Non-steroidal anti-inflammatory 2.8mg/kg)
Bachiocco 1990 [58]	126	Thoracic surgery	Minnesota Mulitphasic Personality Inventory, Eysenck Personality Inventory, STAI, VAS, latency of pain (between wakening to reported onset) and duration of pain	Preop STAI, MMPI, EPI, Postop STAI (1st day postop); postop pain daily at 16.00 by VAS and current postop pain on 1st postop day. Latency (time interval between end of anesth and onset of pain, duration (no of days patient experienced pain)	Pain intensity, latency and duration

APAIS = Amsterdam preoperative anxiety and information scale; anesth = anesthetics; ASA I-III = American Society of Anesthesiologists physical status scale 1 to 3; ASU = ambulatory surgical unit; BDI = Beck depression inventory; BSI = brief symptom inventory; COPE = coping scale; CS = Caesarean section; d/c = discharge; ENT = ear, nose, and throat; EPI = Eysenck personality inventory; EPQ = Eysenck personality questionnaire; GA = general anesthesia; HADS = hospital anxiety and depression scale; HLOC = Health locus of control scale; ICU = intensive care unit; IES = impact event scale; IM = intramuscular; IV = intravenous; KHOS = Kranz health opinion survey; max-fax = maxillary-facial; MCS = Marlowe–Crowne scale; MFAI = modified functional assessment inventory; MMPI = Minnesota multiphasic personality inventory; MPQ = McGill pain questionnaire; NRS = numeric rating scale; op = operation; OR = operating room; PACU = postanesthesia care unit; PADS = postanesthesia discharge score; PCA = patient-controlled analgesia; PCEA = patient-controlled epidural analgesia; postop = postoperative; PPI = present pain intensity; preop = preoperative; PRIT = pain-rating index total, an estimate of overall pain intensity; pt = patient; Qu = questionnaire; SAS = self-rating anxiety scale; SC = subcutaneous; SDS = sensitizing defensive scale; SRQ-D = self-rating questionnaire for depression; STAI = Speilberger state–trait anxiety inventory; sx = surgery; TURP = transurethral resection of prostate; TV = transvaginal; VAS = visual analog scale; VASM = visual analog scale on movement; VASR = visual analog scale at rest; VS = verbal score; W-D = Wolfer-Davis scale.

intrusive thought/avoidant behavior were found to have positive correlations with postoperative analgesic consumption. There were two studies that failed to show a significant correlation between pain catastrophizing and postoperative pain[62] and analgesic consumption[52] (tables 2 and 3), but they both had small sample size and insufficient statistical power ($1 - \beta = 0.4$ and 0.6).

Preoperative Pain. This factor can be divided into three subcategories: preoperative pain/analgesic experience, patient's perception regarding pain or analgesia, and pain threshold.

Preoperative pain experience was a common predictor of postoperative pain intensity. A positive correlation was found in six studies,[23,30,33,46–48] and negative correlation was found in one study[20] (table 2). Preoperative existing pain was also found to have positive correlation with postoperative analgesic consumption[46,64] (table 3). There were three studies failing to show preoperative

Table 5. Summary of the Quality Assessment of the Studies

	Mixed surgical groups															Gastrointestinal surgery											
Reference	117	45	43	34	33	30	19	118	64	26	66	37	27	36	40	29	44	52	49	48	47	39	25	41	46	53
Study ID	Aubrun 2008	Gagliese 2008	Chang 2006	Bandyopadhyay 2007	Mamie 2004	Kalkman 2003	Cepeda 2003	Pavlin 2002	Aubrun 2002	Chia 2002	Dahmani 2001	Thomas 1998	Chung 1997	Puntillo 1994	Voulgari 1991	De Cosmo 2008	Coulbault 2006	Granot 2005	Lau 2004	Caumo 2002	Bisgaard 2001	Ure 1994	Boeke 1991	Weir 1990	Taenzer 1986	Scott 1983
Sampling	F	U	P	U	F	F	U	U	P	P	U	P	P	N	P	P	P	U	U	P	P	F	P	U	P	P
Predictive factors	F	F	U	U	F	F	P	F	P	F	P	F	F	P	F	F	P	F	F	F	F	F	P	U	F	F
Analysis	F	P	F	U	P	P	F	P	U	P	P	U	F	P	P	P	U	U	U	P	U	N	P	P	P	P
Follow-up	U	P	U	N	P	P	U	U	U	F	P	N	P	U	N	P	F	P	P	U	P	F	P	N	U	U

	Obstetrics and gynecology surgery																Breast surgery		Orthopedic surgery		Thoracic surgery	
Reference	57	23	63	32	22	28	54	56	65	50	55	20	38	35	59	119	31	60	62	42	61	58
Study ID	Katz 2008	Rudin 2008	Strulov 2007	Keogh 2006	Pan 2006	Cohen 2005	Hsu 2005	Pud 2005	Granot 2003	Munafo 2003	Kain 2000	Healey 1998	Thomas 1995	Perry 1994	Jamison 1993	Fraser 1989	Katz 2005	Ozalp2003	Roth 2007	Aubrun 2003	Bachiocco 1996	Bachiocco 1990
Sampling	P	P	U	P	U	P	P	P	U	U	P	U	N	N	U	P	P	P	P	U	P	P
Predictive factors	F	F	P	F	F	F	F	P	P	F	F	P	F	U	F	F	F	F	F	P	F	P
Analysis	P	U	U	P	P	P	U	U	U	P	U	P	P	U	P	U	P	U	P	U	U	P
Follow-up	U	P	F	P	U	P	U	U	U	P	P	P	P	P	F	P	F	U	U	P	P	U

F = full meeting criteria in subgroups; N = not meeting criteria in subgroups; P = partially meeting criteria in subgroups; U = unsure if meeting criteria in subgroups. Studies with N for any quality category were excluded form final conclusion of the review.

Table 6. Summary of the Limitations in the Quality of the Studies

Surgical Group	Total No. of Studies	Total No. of Patients	Limitations in the Quality of Studies	Incidence*
Mixed surgery	15	19,083	Sampling	25%
			Inclusion or exclusion criteria not outlined[19,34,36,37]	27%
			The stage of the preoperative measurements not clear[30,36,37,43]	75%
			Preoperative baseline pain score not reported (reported only in 4 studies[30,33,37,117])	
			Predictive factors	
			No standardized or validated psychometric instruments	20%
			Analysis	
			Measures to avoid collinearity not reported (collinearity was avoided in 4 trials[19,27,43,117])	73%
			No validation of the prognostic models (validation was carried out in 2 studies[30,33])	87%
			All the predictors not clearly listed[34,64]	13%
			Follow up	
			Follow up rate (at least 80%) not clearly stated	78%
			No trained or blinded interviewers (interviews were conducted in 7 studies,[27,30,33,34,36,37,40] with only 43% of those had trained or blinded interviewers[27,30,33])	57%
Gastrointestinal surgery	11	2,028	Sampling	
			Preoperative baseline pain score not reported (reported only in 4 studies[25,39,46,53])	64%
			Analysis	
			All the predictors not clearly listed[39,49,52]	27%
			Measures to avoid collinearity not reported	100%
			No validation of the prognostic models	100%
			Insufficient sample size to avoid overfitting of the data (no overfitting in 5 studies[25,29,41,44,48])	55%
			Follow-up	
			Follow-up rate (at least 80%) not clearly stated (this was clearly mentioned in 3 trials[29,39,44])	78%
			No trained or blinded interviewers (3 studies carried out interviews, but only 1 used trained interviewers and blinded interviewers[48])	66%
Obstetrics and gynecology	16	1,064	Sampling	
			Inclusion or exclusion criteria not outlined (only 60% stated clearly the inclusion and exclusion criteria[22,28,32,50,54–57,119])	40%
			The stage of the preoperative measurements not clear[20]	19%
			Predictive factors	
			No standardized or validated psychometric instruments	7%
			Analysis	
			All the predictors not clearly listed	31%
			Measures to avoid collinearity not reported (only 19% mentioned the avoidance of collinearity[20,22,23,35,38])	81%
			No validation of the prognostic models	100%
			Follow-up	
			Follow-up rate (at least 80%) not clearly stated	69%
Breast surgery	2	213	Sampling	
			Inclusion or exclusion criteria not outlined	50%
			Preoperative baseline pain score not reported	50%
			Analysis	
			Measures to avoid collinearity or overfitting not reported[60]	50%
			No validation of the prognostic models	100%
			Follow-up	
			Follow-up rate (at least 80%) not clearly stated	50%
Orthopedic surgery	2	397	Sampling	
			Inclusion or exclusion criteria not outlined[62]	50%
			Analysis	
			Measures to avoid collinearity or overfitting not reported[42]	50%
			No validation of the prognostic models	100%
			Follow-up	
			No trained or blinded interviewers[62]	50%

(*continued*)

Table 6. Continued

Surgical Group	Total No. of Studies	Total No. of Patients	Limitations in the Quality of Studies	Incidence*
Thoracic surgery	2	252	Sampling	
			None of the studies had preoperative pain score	
			Analysis	
			Measures to avoid collinearity or overfitting not reported	100%
			No validation of the prognostic models	100%
			Follow-up	
			Follow-up rate (at least 80%) not clearly stated	100%
			No trained or blinded interviewers	50%

* Number of studies having limitations divided by the total number of studies in each group.

pain as a significant predictor of postoperative pain intensity[31,53,62] (fig. 2), but they had insufficient statistical power ($1 - \beta < 0.9$). Inconsistent results were found regarding the correlation among preoperative analgesic experience such as preoperative analgesic use, previous surgery with patient-controlled analgesia, and postoperative pain and analgesic consumption (tables 2 and 3).

Preoperative pain tolerance was another important predictor of postoperative pain and/or analgesic consumption that was found to be significant in six studies[22,23,47,54,63,65] (tables 2 and 3). The relation between pain threshold and postoperative analgesic consumption was studied in only two studies where a significant correlation was shown.[22,54] This factor was mainly examined in obstetrics and gynecology surgery by using different techniques such as heat pain perception,[23] cold pressor pain,[47] suprathreshold pain stimulation.[63,65]

The perception regarding pain or analgesia was shown to have a positive correlation with postoperative pain[22,33,46] and analgesia consumption[59] (tables 2 and 3).

Surgical Factors. Another important predictor was the type of surgery as derived from the mixed surgical group. Abdominal surgery,[26,27,30] orthopedic surgery,[27,30] and thoracic surgery[26] were shown to be positively correlated with postoperative pain. Emergency,[66] major,[66] and abdominal[40] surgery were reported[40,66] to predict postoperative analgesic consumption (tables 2 and 3). Procedures involving cancer[67] and a long duration of surgery[45,66] were also

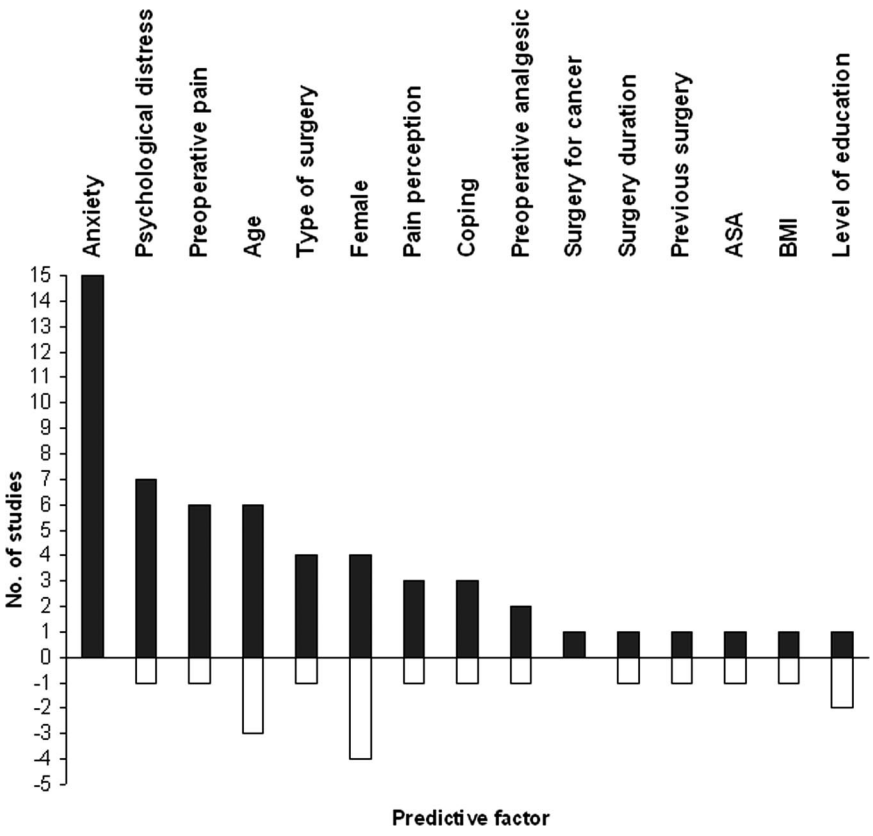

Fig. 2. Predictive factors of postoperative pain intensity. ASA = American Society of Anesthesiologists status; BMI = body mass index (kg/m^2); *black bars* = number of studies with significant correlation; *white bars* = number of studies with conflicting results.

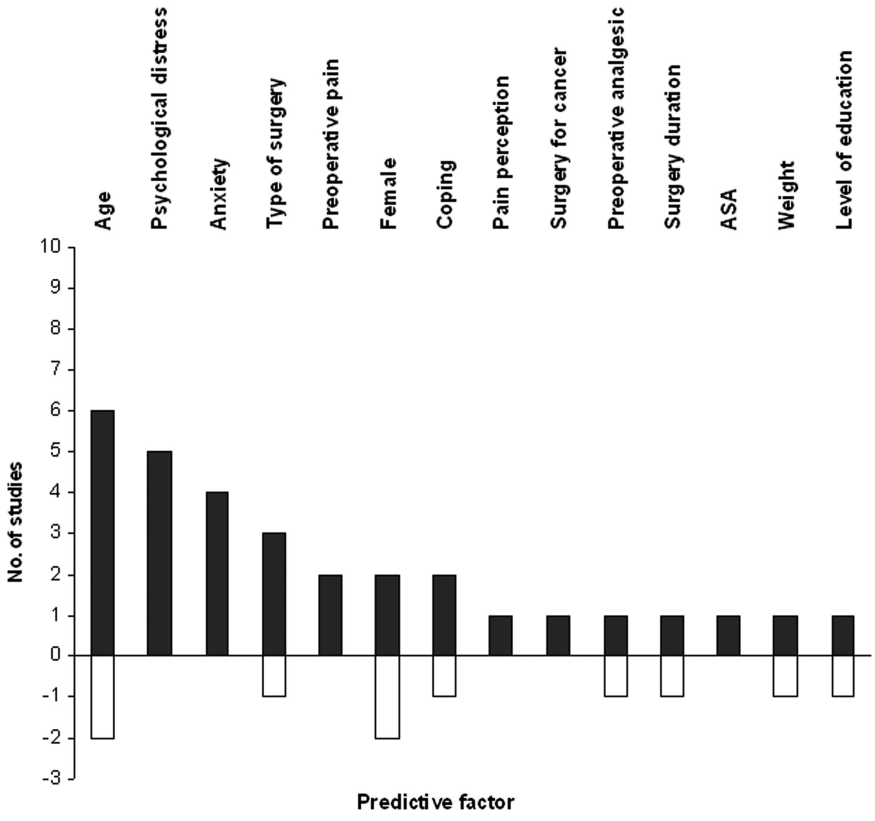

Fig. 3. Predictive factors of postoperative analgesic consumption. ASA = American Society of Anesthesiologists status; BMI = body mass index (kg/m^2); *black bars* = number of studies with significant correlation; *white bars* = number of studies with conflicting results.

found to be correlated to postoperative analgesic consumption (table 3). There were two studies failing to find any correlation between type of surgery and postoperative pain outcomes ($1 - \beta > 0.9$).[26,33]

In summary, preexisting pain, anxiety (or other psychological distress), age, and type of surgery are the four most common variables consistently found to be significant predictors for postoperative pain. For postoperative analgesic consumption, the most consistent predictors are type of surgery, age, and psychological distress (including anxiety). The available literature is conflicting regarding female gender as a predictive factor of postoperative pain or analgesic consumption.

Discussion

Our systematic review found that preexisting pain, anxiety, age, and type of surgery are the four most significant predictive factors for the intensity of postoperative pain. The type of surgery, age, and psychological distress are the three most important predictive factors for postoperative analgesic consumption. Gender was not found as a consistent predictor for postoperative pain or analgesic consumption as traditionally believed.

The type of surgery is found to be a strong predictor for both postoperative pain and analgesic consumption. The most painful operations are orthopedics with major joints surgery, thoracic, and open abdominal surgery.[26,27,30] Surgeries found to have the highest analgesic consumption are emergency, major, and abdominal surgeries.[45,51,66] Different types of surgery have varying degrees of tissue damage, and bone injury is more painful than soft tissue injury, owing to the fact that the periosteum had the lowest pain threshold of the deep somatic structures.[27]

In a study of 10,008 patients undergoing ambulatory surgery, Chung *et al.* reported that urology, general surgery, and orthopedic surgery were at least 17 times more likely to produce pain than ophthalmology surgery.[27] Neurosurgery, gynecology, and plastic surgery were at least nine times more likely to produce pain than ophthalmology.[27] Our review also showed that patients undergoing abdominal and emergency surgeries require more analgesic.[40,66] It is possible that patients who had emergency operations may have less preoperative information[66] and time for psychological preparation resulting in the increased requirement of postoperative analgesia.

Psychosocial and behavioral factors are often neglected in the management of postoperative pain.[68] In our systematic review, anxiety was found to be an important predictor for postoperative pain, especially in gastrointestinal, obstetrical, and gynecological surgery. An anxious state has been advocated as a factor in lowering pain threshold,[69] facilitating overestimation of pain intensity,[70] and activation in the entorhinal cortex of the hippocampal formation.[71] The state-trait anxiety theory predicts individuals with high trait-anxiety are generally hypersensitive to stimuli and psychologically more reactive,[72] albeit state anxiety in response to

the environment is also an important predictor. Good patient communication, development of rapport, reassurance, preoperative anxiolytics if not contraindicated are just a few measures that could be implemented to reduce the preoperative anxiety in an attempt to decrease postoperative pain.

Anxiety also predicts postoperative analgesic consumption, especially in obstetrics and gynecology surgery. There are studies showing no relation between anxiety and postoperative analgesic consumption, but they are studies with small sample size that add to the type II error in the regression analysis that predominantly detects a correlation.

Psychological distress such as depressive mood, and negative affect can increase postoperative analgesic consumption. Normally, mild level of depressive symptoms had not been identified or recognized as having clinical repercussions, especially in patients without psychiatric diagnosis.[73] However, the negative effect of depressed mood on postoperative pain immediately after surgery has been described, such as a transient suppression of the immune function,[74] higher mortality, and a longer convalescence.[75] The relationship between depressed mood and the development of postoperative chronic pain has also been suggested.[76] Therefore, it is imperative that this aspect be taken into account to improve postoperative pain management and possibly also disrupt the processes responsible for the transition to chronicity of pain.[48]

Other significant psychosocial or behavioral factors are coping strategies, including pain catastrophization. This may be the result of an increased expression of pain or focus of pain.[77] However, diverting attention may not be an effective strategy for people who catastrophize about pain,[78,79] and catastrophizing may need to be reduced before distraction can be effective.[80,81] Pain catastrophization was also found to have a positive correlation with postoperative pain in two studies.[63,65] The correlation between pain catastrophization and pain has been described previously.[82,83] The mechanisms are poorly understood but some suggested that thought intrusion may be interpreted as signals of coping failure, thereby increasing the threat value of the pain stimulus. Furthermore, catastrophizers may have come to expect that their pain experience will be high regardless of variations in thought intrusions.[83] Cognitive behavioral strategies may be helpful in dealing with thought process and pain-related ideation.

Preexisting pain, chronic pain, and low preoperative pain threshold[22,23,47,54,63,65] are also significant predicting factors for postoperative pain. Intense influx of pain signal from tissue trauma after surgery can lead to enhancement of excitability and responsiveness of dorsal horn neurons to pain transmission.[84] Their excitability can be further sustained by transcriptional changes, such as induction of genes cyclooxygenase-2 (COX-2) inhibitors leading to prostaglandin E_2 (PGE_2) production. As a result, the pain may persist beyond apparent tissue healing, leading to chronic postsurgical pain syndromes.[85] A growing body of evidence suggests that improvement in postoperative pain management might disrupt the transition to chronicity of pain.[48,57,85–88]

Genetic polymorphisms also contributed to a number of specific pain phenotypes. Mogil *et al.* provided evidence for at least five fundamental types of nociception and hypersensitivity: baseline thermal nociception, spontaneous responses to noxious chemical stimuli, thermal hypersensitivity, baseline mechanical sensitivity, and afferent input-dependent hypersensitivity.[89,90] In addition, there is positive evidence for the correlation between genetic polymorphisms and altered pain perception and processing, ranging from the μ-opioid receptor gene to specialized pain transducing receptors expressed in primary afferent neurons, such as the heat/capsaicin sensing vanilloid receptor ionophore-1 through to interleukin-1 proinflammatory cytokine.[91–93]

It was recently demonstrated that a mutation of the μ-opioid receptor gene increased binding affinity to β-endorphin, resulting in a reduction in pain sensitivity in healthy adults.[94] There has also been suggestion that the catechol-o-methyltransferase (COMT) genotype is associated with pain reports and pain-induced brain opioid receptor binding such that individuals with a particular genotype had a higher sensory and affective pain rating.[95] Another COMT genotype has been reported to be less pain-sensitive.[96] Furthermore, it has recently been demonstrated that the interleukin-1 receptor antagonist (IL-1Ra) polymorphism plays a role in predicting postoperative morphine consumption.[97]

In most individuals, the experience and susceptibility of pain results from a complex interaction among several genetic variants involved in different steps of neuronal processing of nociceptive information with additional contributions of other genetic or psychosocial factors, sociocultural environment, and prior learning. Furthermore, different genes may be involved in different kinds of pain, their sensory and affective dimensions, all intertwining with another, resulting in highly variable responses across individuals.[91,93,98] This field is still in its infancy, and much research is needed to explore the variety of polymorphisms and their interactions.

In general, age and gender are traditionally believed to be predictors for postoperative pain and analgesic consumption. We found that the results from the different studies were conflicting, especially for these two predictors. It could be due to the difference in sampling population; for example, Chia *et al.* examined only the Chinese population.[26] Other studies had small sample size,[23,29,50] which was relatively insufficient to detect an existing correlation between age and postoperative pain. The statistical methods were of variable standards. Many studies did not state whether collinearity was avoided.[29,30,33,48] Others might have studied

many covariates for the sample size, creating an overfitting of the data.[23,33] To minimize bias in our final results, the studies were critically appraised, and the conclusion was drawn from studies of sound quality and of sufficient power. In our review, age was found to be a significant predictor for both postoperative pain and even more so for analgesic consumption.

Age has been suggested to have blunted the peripheral nociceptive function, decreasing pain in some contexts and reduced morphine requirements.[35] However, the presence of persistent or recurrent clinical pain may have a greater effect on the psychological, social, and physical function of older adults.[99] There could also be potential confounding factors such as the confusion of elderly people with patient-controlled analgesia and the underreporting and exclusion of patients over the age of 70 yr from studies.[26] Elderly patients have been noted to be more susceptive to the effects of opioid analgesia than young patients,[100–102] and some phases of pharmacokinetics are affected in aging, such as distribution,[103] metabolism,[104,105] and elimination.[105,106] Some studies showed that analgesic use declined with advancing age,[43,45] whereas others were unable to show a relationship.[26,64] In older patients, fewer opioids were prescribed and consumed, but pain in the elderly population can induce postoperative cardiopulmonary complications, ileus, nausea, and vomiting,[107] and each patient should be considered on an individual basis. However, for those aged greater than 75 yr, Aubrun *et al.* did not observe any difference in analgesic consumption.[108] There is also evidence that advancing age appears to reduce the influence of specific genes on the experience of pain.[93]

Our review showed a conflicting result for gender as a predictor for either postoperative pain or analgesic consumption. Gender differences in pain perception and analgesic consumption remain tentative, and age may be a confounding factor. The mechanism for gender differences is still elusive. There is some evidence that genetics plays a part in influencing interindividual variation in clinical and experimental pain responses.[109] It can also be attributed to a different socialization processes for men and women that influence bodily experience and the willingness to communicate distress.[110] Hormone variations,[111] neurotransmitters that can influence patient perception of pain, and pharmacokinetic variations may also occur.[112] Nevertheless, the difference could reflect pain reporting bias, patient belief in analgesic requirement and unwarranted psychogenic attributions made by health care providers.[113,114] On the other hand, Chia *et al.* reported reduced morphine consumption by Chinese women in the first 3 postoperative days compared to men. It should be noted that two-thirds of the patients were female in that study. It is also possible that cultural, ethnic, or genetic factors may account for the differing findings in the Chinese study.[84]

The knowledge of the important predictive factors for postoperative pain and analgesic consumption will enable early recognition of the at-risk patients. This will help in formulating an appropriate plan for effective pain management postoperatively and to attend to the pain considering the four predictors of pain, namely, preexisting pain, anxiety, age, and type of surgery.

Type of surgery is often interpreted only as a different subspecialty. Our review demonstrates that we should have a high suspicion for patients undergoing orthopedic, thoracic, and abdominal surgery or major and emergency surgery. We also need to be aware of those patients suffering from preexisting acute or chronic pain. They may have a higher postoperative pain and analgesic requirement. Furthermore, we must not forget the potential impact of psychological factors on the postoperative pain and analgesic requirement. We can discuss and educate our patients regarding concerns related to anxiety and coping strategies and provide anxiolytics or other medication as clinically indicated.[115] This review also raises questions regarding whether gender is predictive of postoperative pain and analgesic consumption as traditionally believed. Nonetheless, our systematic review provides a better insight into the predictors of postoperative pain such that future studies should take this into consideration in study design since these predictors are dependent variables.

This systematic review has several limitations that may explain the lack of consistency across the studies. The first limitation of this review is that in studies of prognostic models, none of the criteria of quality assessment have been widely accepted. The main problem with quality scores was to determine the weight that each item should provide to the overall score and the cutoffs for high-quality studies and poor-quality studies.[116] A number of studies have questionable quality, and others are limited by methodology problems; for example, the absence of standardized measuring instruments for the psychological variables may explain some of the inconsistent findings for postoperative pain. Therefore, we have excluded the poor quality studies in our final conclusion. The explanation for conflicting results in some predictors could be secondary to a lack of sufficient studies examining the factors in question. For regression analysis, the variables showing no correlation are not generally reported, and type II error can be introduced, which is affected by the sample size. We are unable to pool the data in this systematic review because it is impractical to obtain the raw data from every study that spans over a few decades. To minimize this problem, we discounted those studies with small sample size whose variables did not show any correlation when drawing the final conclusion. Different studies also looked at pain intensity and analgesic consumption at different time period postoperatively, together with the different analgesic regimes making comparison between studies diffi-

cult. Furthermore, pain itself is difficult to define because the measure of pain intensity is a subjective entity, and the quality of pain was not usually measured, for example, *via* McGill Pain Questionnaire; therefore, the use of visual analogue score may not reflect the actual pain experienced.

Uncontrolled anesthetic management, the nonhomogenous patient populations, different follow-up time period, and uncontrolled surgical procedure variables were all possible confounders. The age range of the studies is not large enough to show a significant difference, and not all studies examined age as a predictive factor. There could also be potential confounding factors such as the confusion of elderly people with patient-controlled analgesia and underreporting and exclusion of patients over the age of 70 yr from some studies.[26] It is possible that older patients are less inclined to complain to medical and nursing staff, resulting in reporting bias.[50]

The R^2 is a statistical value expressed in percentage that quantifies the extent to which a variable can be predicted by a given logistic regression model. The higher the percentage, the greater contribution the variable in question has on a particular independent variable. For the majority of the predictors, it was below 54%, leaving about half of the variability not explained by the measured variables. Furthermore, different studies measured different variables, and very few studies analyzed all the demographic, psychosocial, and surgical predictors simultaneously as independent factors into the models of regression analysis. Further research on the predictors of postoperative pain is needed.

In conclusion, preexisting pain, anxiety, age, and type of surgery are the four most significant predictors for postoperative pain. Type of surgery, age, and psychological distress were those for postoperative analgesic consumption. Gender was not found to be a significant predictor as traditionally believed. Early identification of the predictors in patients at risk of postoperative pain and an increased awareness of the importance of the psychological factors will allow more effective intervention and better pain management. There is a need for further studies to investigate a wide range of variables using sound instruments and clear definitions of pain intensities or pain control with analgesic consumption. This is especially true in orthopedic and breast surgery, where very painful procedures are performed with a limited amount of studies. Studies should be of a large-scale and ideally homogenous in terms of demographics, medical and psychological history, underlying pathology such as malignancy, and surgical procedure.

Appendix: Assessment Tools for Perioperative Variables and Outcome Measures

The following outlines the various instruments commonly used in the studies for assessing the perioperative risk factors or predictors and outcomes.

Psychological Measures

Mental Health inventory[120]: An 18-item scale measuring symptoms of psychological distress and wellbeing along the five dimensions – anxiety, depression, loss of behavioral/emotional control, positive affect, and interpersonal ties.

26-Item Stress Scale[121,122]: For assessing negative affect and is reliable to measure acute distress. Each item was rated on a five-point scale ranging from "not at all" to "extremely."

Hospital Anxiety and Depression Scale[123]: A self-assessment scale for detecting symptoms of anxiety and depression in nonpsychiatric patients from a medical outpatients department. It contains two seven-item scales: one for anxiety and one for depression with a score ranging from 0–21.

Self-Rating Questionnaire for Depression (SRQ-D)[124]: Examines depressive conditions. The questionnaire consists of 18 items (4 somatic and 8 cognitive). Patients have a choice of four answers to each item: seldom or never (0), some of the time (1), quite often (2), and almost always (3).

Montgomery-Asberg Depression Rating Scale (MADRS)[125]: A tool for measuring depressive symptoms: moderate to intense (>13) or mildly depressive symptoms (≤ 13).

State-Trait Anxiety Inventory[72]: Comprises two self-report scales to measure state anxiety and trait anxiety. Each consists of 20 statements that are used to describe a person's feelings or disposition, a transitory emotional state induced by a particular situation.

Hamilton Depression and Anxiety Rating Scales (HDARS)[126,127]: Completed by a trained clinical psychologist or nurse practitioner who administered structured interviews specifically developed for rating these two scales.

Functional Assessment of Cancer Treatment-Emotion Scale (FACT-E)[128]: Designed to assess mood and anxiety in patients with cancer.

Somatosensory Amplification Scale[129]: A measure of sensitivity to and amplification of unpleasant bodily sensations that may also reflect somatic anxiety.

Illness Behavior Questionnaire Disease Conviction Scale[130]: A measure of symptom preoccupation, rejection of physician reassurance, and affirmation of physical disease that has been found to be a risk factor for the development of postherpetic neuralgia .[131]

Minnesota Multiphasic Personality Inventory (MMPI): A 174-item questionnaire identifying the personality of the subjects.

Eysenck Personality Questionnaire (EPQ)[132]: Used to measure different personality traits such as neuroticism. A typical neurotic patient scoring highly on the EPQ is an anxious, worrying individual who is moody and frequently depressed (range 0–23).

Multidimensional Health Locus of Control Scale (MHLC)[133]: An 18-item questionnaire with three scales.

Each scale contains six items using six response options ranging from strongly agree to strongly disagree.

Impact Event Scale[134]: Fifteen-item self-report scale that assesses two categories of cognitive responses to stressful events: intrusion (intrusively experienced ideas, images, feelings, or bad dreams) and avoidance (consciously recognized avoidance of certain ideas, feelings, or situations).

Brief COPE (Coping scale)[135]: Used to measure coping tendency or style. It measures a set of conceptually distinct coping subscales that include active coping, use of social support, acceptance, venting, humor, religious-based coping, and avoidant coping.

Pain Catastrophizing Scale[136]: A questionnaire that includes 13 items that assess three components: rumination, magnification, and helplessness.

Pain Threshold Measures

Sensory, Mechanical Pain Threshold and Heat Pain Threshold and Perception[131]: A first-degree burn injury was induced with a thermode (7 min at 47 degrees). Patients rated pain intensity at the start and every minute during the burn. The area of secondary hyperalgesia developing around the burn injury was assessed by a rigid von Frey monofilament that would be the mechanical pain threshold and mechanical pain perception in terms of the visual analog scale (VAS). Heat pain threshold was assessed with a contact thermode using a baseline temperature of 32 degrees. Heat pain perception in terms of the VAS was evaluated with a 10-s 45°C heat stimulus in the burn area.

Electronic Pressure Algometer: Used to determine pain threshold and pain tolerance pressure. A probe is applied to the pulp of the finger, and the pressure is increased at a speed of 30 kPa/s. Patients are asked to press a button on a patient-operated switch when they start to feel pain (pain threshold) and when they can no longer stand the pain (pain tolerance). The algometer records the pressure at each point.[54]

Suprathreshold Pain: A magnitude estimation of suprathreshold noxious stimulation assessment performed by applying phasic heat stimuli at four different temperatures: 45°C, 46°C, 47°C, and 48°C. The subjects are asked to report the level of perceived pain intensity by means of a VAS immediately after each stimulus.[63]

Pain Outcome Measures

Mcgill Pain Questionnaire: An instrument developed by Melzack and Torgerson (1971) and based on the Gate control theory of pain[103] composed of four major parts:

Part 1 is the pain rating (PRI) composed of 78 descriptive words that are scaled on intensity and qualitative dimensions.

Part 2 is a present pain intensity (PPI) item that rates the subject's choice of weighted terms to depict the amount of pain felt at the moment.

Part 3 consists of front and back views of the body, and subjects are asked to mark the areas where they are having pain.

Part 4 of the tool is used to record specific symptoms that accompany the pain.

Visual Analogues Scale: An ungraduated 10-cm-long scale, scored on the left extremity with either "no pain at all" or "very effective treatment" and on the right extremity with either "unbearable pain" or "ineffective treatment."

Numerical Rating Scores/Numerical Pain Score: An example of this scoring system is the 11-point numerical rating score of 1–10, where 0 is no pain and 10 is the worst imaginable pain.

Brief Pain Inventory[137]: A method to measure pain intensity and the extent to which pain interferes with life.

The authors thank Marina Englesakis, B.A. (Hons), M.L.I.S. Information Specialist, Librarian, Toronto Western Hospital, Toronto, Ontario, Canada, for her help with the literature search.

References

1. McCaffery M: Pain: Clinical manual for nursing practice, 2nd edition. Mosby, St Louis, 1989, pp 7.
2. Kiecolt-Glaser JK, Page GG, Marucha PT, MacCallum RC, Glaser R: Psychological influences on surgical recovery. Perspectives from psychoneuroimmunology. Am Psychol 1998; 53:1209–18
3. Akca O, Melischek M, Scheck T, Hellwagner K, Arkilic CF, Kurz A, Kapral S, Heinz T, Lackner FX, Sessler DI: Postoperative pain and subcutaneous oxygen tension. Lancet 1999; 354:41–2
4. Ballantyne JC, Carr DB, de Ferranti S, Suarez T, Lau J, Chalmers TC, Angelillo IF, Mosteller F: The comparative effects of postoperative analgesic therapies on pulmonary outcome: Cumulative meta-analyses of randomized, controlled trials. Anesth Analg 1998; 86:598–612
5. Beattie WS, Buckley DN, Forrest JB: Epidural morphine reduces the risk of postoperative myocardial ischaemia in patients with cardiac risk factors. Can J Anaesth 1993; 40:532–41
6. Scarry E: The body in pain. Oxford, Oxford University Press, 1985.
7. Chung F, Un V, Su J: Postoperative symptoms 24 hours after ambulatory anaesthesia. Can J Anaesth 1996; 43:1121–7
8. Hayden JA, Cote P, Bombardier C: Evaluation of the quality of prognosis studies in systematic reviews. Ann Intern Med 2006; 144:427–37
9. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM: Systematic review of psychosocial factors at work and private life as risk factors for back pain. Spine 2000; 25:2114–25
10. Iles RA, Davidson M, Taylor NF: Psychosocial predictors of failure to return to work in non-chronic non-specific low back pain: A systematic review. Occup Environ Med 2008; 65:507–17
11. Linton SJ: A review of psychological risk factors in back and neck pain. Spine 2000; 25:1148–56
12. Bax L, Yu LM, Ikeda N, Tsuruta H, Moons KG: Development and validation of MIX: Comprehensive free software for meta-analysis of causal research data. BMC Med Res Methodol 2006; 6:50
13. Bax L, Yu LM, Ikeda N, Tsuruta N, Moons KGM: MIX: Comprehensive free software for meta-analysis of causal research data - version 1.7. MIX. 2008.
14. McNeill G, Tuya C, Smith WC: The role of genetic and environmental factors in the association between birthweight and blood pressure: Evidence from meta-analysis of twin studies. Int J Epidemiol 2004; 33:995–1001
15. Higgins JPT, Green S: Cochrane Handbook for Systematic Reviews of Interventions. Version 5.0.1. The Cochrane Collaboration. 2008.
16. Sharp DS, Gahlinger PM: Regression analysis in biological research: Sample size and statistical power. Med Sci Sports Exerc 1988; 20:605–10
17. Siu A, Herse P: The effect of age on human corneal thickness. Statistical implications of power analysis. Acta Ophthalmol 1993; 71:51–6
18. Bachiocco V, Morselli AM, Carli G: Self-control expectancy and postsurgi-

cal pain: Relationships to previous pain, behavior in past pain, familial pain tolerance models, and personality. J Pain Symptom Manage 1993; 8:205–14

19. Cepeda MS, Carr DB: Women experience more pain and require more morphine than men to achieve a similar degree of analgesia. Anesth Analg 2003; 97:1464–8

20. Healey M, Maher P, Hill D, Gebert R, Wein P: Factors associated with pain following operative laparoscopy: A prospective observational study. Aust N Z J Obstet Gynaecol 1998; 38:80–4

21. Jamison RN, Parris WC, Maxson WS: Psychological factors influencing recovery from outpatient surgery. Behav Res Ther 1987; 25:31–7

22. Pan PH, Coghill R, Houle TT, Seid MH, Lindel WM, Parker RL, Washburn SA, Harris L, Eisenach JC: Multifactorial preoperative predictors for postcesarean section pain and analgesic requirement. ANESTHESIOLOGY 2006; 104:417–25

23. Rudin A, Wolner-Hanssen P, Hellbom M, Werner MU: Prediction of postoperative pain after a laparoscopic tubal ligation procedure. Acta Anaesthesiol Scand 2008; 52:938–45

24. Wise TN, Hall WA, Wong O: The relationship of cognitive styles and affective status to post-operative analgesic utilization. J Psychosom Res 1978; 22:513–8

25. Boeke S, Duivenvoorden HJ, Verhage F, Zwaveling A: Prediction of postoperative pain and duration of hospitalization using two anxiety measures. Pain 1991; 45:293–7

26. Chia YY, Chow LH, Hung CC, Liu K, Ger LP, Wang PN: Gender and pain upon movement are associated with the requirements for postoperative patient-controlled iv analgesia: A prospective survey of 2,298 Chinese patients. Can J Anaesth 2002; 49:249–55

27. Chung F, Ritchie E, Su J: Postoperative pain in ambulatory surgery. Anesth Analg 1997; 85:808–16

28. Cohen L, Fouladi RT, Katz J: Preoperative coping strategies and distress predict postoperative pain and morphine consumption in women undergoing abdominal gynecologic surgery. J Psychosom Res 2005; 58:201–9

29. De Cosmo G, Congedo E, Lai C, Primieri P, Dottarelli A, Aceto P: Preoperative psychologic and demographic predictors of pain perception and tramadol consumption using intravenous patient-controlled analgesia. Clin J Pain 2008; 24:399–405

30. Kalkman CJ, Visser K, Moen J, Bonsel GJ, Grobbee DE, Moons KG: Preoperative prediction of severe postoperative pain. Pain 2003; 105:415–23

31. Katz J, Poleshuck EL, Andrus CH, Hogan LA, Jung BF, Kulick DI, Dworkin RH: Risk factors for acute pain and its persistence following breast cancer surgery. Pain 2005; 119:16–25

32. Keogh E, Hughes S, Ellery D, Daniel C, Holdcroft A: Psychosocial influences on women's experience of planned elective cesarean section. Psychosom Med 2006; 68:167–74

33. Mamie C, Bernstein M, Morabia A, Klopfenstein CE, Sloutskis D, Forster A: Are there reliable predictors of postoperative pain? Acta Anaesthesiol Scand 2004; 48:234–42

34. Bandyopadhyay M, Markovic M, Manderson L: Women's perspectives of pain following day surgery in Australia. Aust J Adv Nurs 2007; 24:19–23

35. Perry F, Parker RK, White PF, Clifford PA: Role of psychological factors in postoperative pain control and recovery with patient-controlled analgesia. Clin J Pain 1994; 10:57–63

36. Puntillo K, Weiss SJ: Pain: Its mediators and associated morbidity in critically ill cardiovascular surgical patients. Nurs Res 1994; 43:31–6

37. Thomas T, Robinson C, Champion D, McKell M, Pell M: Prediction and assessment of the severity of post-operative pain and of satisfaction with management. Pain 1998; 75:177–85

38. Thomas V, Heath M, Rose D, Flory P: Psychological characteristics and the effectiveness of patient-controlled analgesia. BJA 1995; 74:271–6

39. Ure BM, Troidl H, Spangenberger W, Dietrich A, Lefering R, Neugebauer E: Pain after laparoscopic cholecystectomy. Intensity and localization of pain and analysis of predictors in preoperative symptoms and intraoperative events. Surg Endosc 1994; 8:90–6

40. Voulgari A, Lykouras L, Papanikolaou M, Tzonou A, nou-Roussaki A, Christodoulou G: Influence of psychological and clinical factors on postoperative pain and narcotic consumption. Psychother Psychosom 1991; 55:191–6

41. Weir R, Roberts J, Browne GB, Crook J, Barnes W: Predictors of narcotic analgesic administration in the first 48 post-operative hours. Can J Nurs Res 1990; 22:61–73

42. Aubrun F, Bunge D, Langeron O, Saillant G, Coriat P, Riou B: Postoperative morphine consumption in the elderly patient. ANESTHESIOLOGY 2003; 99:160–5

43. Chang KY, Tsou MY, Chiou CS, Chan KH: Correlations between patient-controlled epidural analgesia requirements and individual characteristics among gynecologic patients. Acta Anaesthesiol Taiwan 2006; 44:135–40

44. Coulbault L, Beaussier M, Verstuyft C, Weickmans H, Dubert L, Tregouet D, Descot C, Parc Y, Lienhart A, Jaillon P, Becquemont L: Environmental and genetic factors associated with morphine response in the postoperative period. Clin Pharmacol Ther 2006; 79:316–24

45. Gagliese L, Gauthier LR, Macpherson AK, Jovellanos M, Chan VW: Correlates of postoperative pain and intravenous patient-controlled analgesia use in younger and older surgical patients. Pain Med 2008; 9:299–314

46. Taenzer P, Melzack R, Jeans ME: Influence of psychological factors on postoperative pain, mood and analgesic requirements. Pain 1986; 24:331–42

47. Bisgaard T, Klarskov B, Rosenberg J, Kehlet H: Characteristics and prediction of early pain after laparoscopic cholecystectomy. Pain 2001; 90:261–9

48. Caumo W, Schmidt AP, Schneider CN, Bergmann J, Iwamoto CW, Adamatti LC, Bandeira D, Ferreira MB: Preoperative predictors of moderate to intense acute postoperative pain in patients undergoing abdominal surgery. Acta Anaesthesiol Scand 2002; 46:1265–71

49. Lau H, Patil NG: Acute pain after endoscopic totally extraperitoneal (TEP) inguinal hernioplasty: Multivariate analysis of predictive factors. Surg Endosc 2004; 18:92–6

50. Munafo MR, Stevenson J: Selective processing of threat-related cues in day surgery patients and prediction of post-operative pain. Br J Health Psychol 2003; 8:439–49

51. Chang KY, Dai CY, Ger LP, Fu MJ, Wong KC, Chan KH, Tsou MY: Determinants of patient-controlled epidural analgesia requirements: A prospective analysis of 1,753 patients. Clin J Pain 2006; 22:751–6

52. Granot M, Ferber SG: The roles of pain catastrophizing and anxiety in the prediction of postoperative pain intensity: A prospective study. Clin J Pain 2005; 21:439–45

53. Scott LE, Clum GA, Peoples JB: Preoperative predictors of postoperative pain. Pain 1983; 15:283–93

54. Hsu YW, Somma J, Hung YC, Tsai PS, Yang CH, Chen CC: Predicting postoperative pain by preoperative pressure pain assessment. ANESTHESIOLOGY 2005; 103:613–8

55. Kain ZN, Sevarino F, Alexander GM, Pincus S, Mayes LC: Preoperative anxiety and postoperative pain in women undergoing hysterectomy. A repeated-measures design. J Psychosom Res 2000; 49:417–22

56. Pud D, Amit A: Anxiety as a predictor of pain magnitude following termination of first-trimester pregnancy. Pain Med 2005; 6:143–8

57. Katz J, Buis T, Cohen L: Locked out and still knocking: Predictors of excessive demands for postoperative intravenous patient-controlled analgesia. Can J Anaesth 2008; 55:88–99

58. Bachiocco V, Morselli-Labate AM, Rusticali AG, Bragaglia R, Mastrorilli M, Carli G: Intensity, latency and duration of post-thoracotomy pain: relationship to personality traits. Funct Neurol 1990; 5:321–32

59. Jamison RN, Taft K, O'Hara JP, Ferrante FM: Psychosocial and pharmacologic predictors of satisfaction with intravenous patient-controlled analgesia. Anesth Analg 1993; 77:121–5

60. Ozalp G, Sarioglu R, Tuncel G, Aslan K, Kadiogullari N: Preoperative emotional states in patients with breast cancer and postoperative pain. Acta Anaesthesiol Scand 2003; 47:26–9

61. Bachiocco V, Rucci P, Carli G: Request of analgesics in post-surgical pain. Relationships to psychological factors and pain-related variables. Pain Clinic 1996; 9:169–79

62. Roth ML, Tripp DA, Harrison MH, Sullivan M, Carson P: Demographic and psychosocial predictors of acute perioperative pain for total knee arthroplasty. Pain Res Manage 2007; 12:185–94

63. Strulov L, Zimmer EZ, Granot M, Tamir A, Jakobi P, Lowenstein L: Pain catastrophizing, response to experimental heat stimuli, and post-cesarean section pain. J Pain 2007; 8:273–9

64. Aubrun F, Monsel S, Langeron O, Coriat P, Riou B: Postoperative titration of intravenous morphine in the elderly patient. ANESTHESIOLOGY 2002; 96:17–23

65. Granot M, Lowenstein L, Yarnitsky D, Tamir A, Zimmer EZ: Postcesarean section pain prediction by preoperative experimental pain assessment. ANESTHESIOLOGY 2003; 98:1422–6

66. Dahmani S, Dupont H, Mantz J, Desmonts JM, Keita H: Predictive factors of early morphine requirements in the post-anaesthesia care unit (PACU). BJA 2001; 87:385–9

67. Chang KY, Tsou MY, Chan KH, Sung CS, Chang WK: Factors affecting patient-controlled analgesia requirements. J Formos Med Assoc 2006; 105:918–25

68. Main CC, Spanswick CC: Pain Management. An interdisciplinary approach. Elsevier Health Sciences, 2000, p xi

69. Rhudy JL, Meagher MW: Fear and anxiety: Divergent effects on human pain thresholds. Pain 2000; 84:65–75

70. al Absi M, Rokke PD: Can anxiety help us tolerate pain? Pain 1991; 46:43–51

71. Ploghaus A, Narain C, Beckmann CF, Clare S, Bantick S, Wise R, Matthews PM, Rawlins JN, Tracey I: Exacerbation of pain by anxiety is associated with activity in a hippocampal network. J Neurosci 2001; 21:9896–903

72. Spielberger CD, Gorsuch R, Lushene R: The state-trait anxiety inventory. Consulting Psychologists Press, Palo Alto, California, 1970

73. Snaith RP, Harrop FM, Newby DA, Teale C: Grade scores of the Montgomery-Asberg Depression and the Clinical Anxiety Scales. Br J Psychiatry 1986; 148:599–601

74. Linn BS, Linn MW, Klimas NG: Effects of psychophysical stress on surgical outcome. Psychosom Med 1988; 50:230–44

75. Getto CJ: Preoperative depression, Emotional and psychological responses to anesthesia and surgery. Edited by Guerra F, Aldrete JA. New York, Grune and Straton Inc., 1980, pp 9–18.

76. Tasmuth T, Estlanderb AM, Kalso E: Effect of present pain and mood on the memory of past postoperative pain in women treated surgically for breast cancer. Pain 1996; 68:343–7

77. Buck R, Morley S: A daily process design study of attentional pain control strategies in the self-management of cancer pain. Eur J Pain 2006; 10:385–98

78. Goubert L, Crombez G, Eccleston C, Devulder J: Distraction from chronic pain during a pain-inducing activity is associated with greater post-activity pain. Pain 2004; 110:220–7

79. Heyneman NE, Fremouw WJ, Gano D, Kirkland F, Heiden L: Individual differences and the effectiveness of coping strategies for pain. Cogn Ther Res 1990; 14:63–77

80. Vlaeyen JWS, Nooyen-Haazen IWCJ, Goossens MEJB, van Breukelen G, Heuts PHTG, Goei H: The role of fear in the cognitive-educational treatment of fibromyalgia, Eighth World Congress on Pain. Edited by Jensen TS, Turner JA, Wiesenfeld-Hallin Z. Seattle, WA, IASP Press, 1997, pp 693–704.

81. Roelofs J, Peters ML, van der ZM, Vlaeyen JW: Does fear of pain moderate the effects of sensory focusing and distraction on cold pressor pain in pain-free individuals? J Pain 2004; 5:250–6

82. Pavlin DJ, Sullivan MJ, Freund PR, Roesen K: Catastrophizing: A risk factor for postsurgical pain. Clin J Pain 2005; 21:83–90

83. Sullivan MJ, Bishop S, Pivik J: The catastrophizing scale: Development and validation. Psychol Assess 1995; 7:524–32

84. Scholz J, Woolf CJ: Can we conquer pain? Nat Neurosci 2002; 5 (Suppl): 1062–7

85. Perkins FM, Kehlet H: Chronic pain as an outcome of surgery. A review of predictive factors. ANESTHESIOLOGY 2000; 93:1123–33

86. Katz J, Jackson M, Kavanagh BP, Sandler AN: Acute pain after thoracic surgery predicts long-term post-thoracotomy pain. Clin J Pain 1996; 12:50–5

87. Perttunen K, Tasmuth T, Kalso E: Chronic pain after thoracic surgery: A follow-up study. Acta Anaesthesiol Scand 1999; 43:563–7

88. Yarnitsky D, Crispel Y, Eisenberg E, Granovsky Y, Ben-Nun A, Sprecher E, Best LA, Granot M: Prediction of chronic post-operative pain: Pre-operative DNIC testing identifies patients at risk. Pain 2008; 138:22–8

89. Mogil JS, Wilson SG, Bon K, Lee SE, Chung K, Raber P, Pieper JO, Hain HS, Belknap JK, Hubert L, Elmer GI, Chung JM, Devor M: Heritability of nociception I: Responses of 11 inbred mouse strains on 12 measures of nociception. Pain 1999; 80:67–82

90. Lariviere WR, Wilson SG, Laughlin TM, Kokayeff A, West EE, Adhikari SM, Wan Y, Mogil JS: Heritability of nociception. III. Genetic relationships among commonly used assays of nociception and hypersensitivity. Pain 2002; 97:75–86

91. Lotsch J, Geisslinger G: Current evidence for a genetic modulation of the response to analgesics. Pain 2006; 121:1–5

92. Caterina MJ, Leffler A, Malmberg AB, Martin WJ, Trafton J, Petersen-Zeitz KR, Koltzenburg M, Basbaum AI, Julius D: Impaired nociception and pain sensation in mice lacking the capsaicin receptor. Science 2000; 288:306–13

93. Edwards RR: Genetic predictors of acute and chronic pain. Curr Rheumatol Rep 2006; 8:411–7

94. Fillingim RB, Kaplan L, Staud R, Ness TJ, Glover TL, Campbell CM, Mogil JS, Wallace MR: The A118G single nucleotide polymorphism of the mu-opioid receptor gene (OPRM1) is associated with pressure pain sensitivity in humans. J Pain 2005; 6:159–67

95. Zubieta JK, Heitzeg MM, Smith YR, Bueller JA, Xu K, Xu Y, Koeppe RA, Stohler CS, Goldman D: COMT val158met genotype affects mu-opioid neurotransmitter responses to a pain stressor. Science 2003; 299:1240–3

96. Diatchenko L, Slade GD, Nackley AG, Bhalang K, Sigurdsson A, Belfer I, Goldman D, Xu K, Shabalina SA, Shagin D, Max MB, Makarov SS, Maixner W: Genetic basis for individual variations in pain perception and the development of a chronic pain condition. Hum Mol Genet 2005; 14:135–43

97. Candiotti KA, Yang Z, Bird V, Leveillee R, Gitline MC: Surgical technique or genomics? Predictors of post-operative morphine consumption. ANESTHESIOLOGY 2008; 109:A1583

98. Turk DC: Remember the distinction between malignant and benign pain? Well, forget it. Clin J Pain 2002; 18:75–6

99. Gibson SJ, Katz B, Corran TM, Farrell MJ, Helme RD: Pain in older persons. Disabil Rehabil 1994; 16:127–39

100. Bellville JW, Forrest WH Jr, Miller E, Brown BW Jr: Influence of age on pain relief from analgesics. A study of postoperative patients. JAMA 1971; 217: 1835–41

101. Novak LP: Aging, total body potassium, fat-free mass, and cell mass in males and females between ages 18 and 85 years. J Gerontol 1972; 27:438–43

102. Wall RT III: Use of analgesics in the elderly. Clin Geriatr Med 1990; 6:345–64

103. Chauvin M, Sandouk P, Scherrmann JM, Farinotti R, Strumza P, Duvaldestin P: Morphine pharmacokinetics in renal failure. ANESTHESIOLOGY 1987; 66: 327–31

104. Greenblatt DJ, Sellers EM, Shader RI: Drug therapy: Drug disposition in old age. N Engl J Med 1982; 306:1081–8

105. Kaiko RF: Age and morphine analgesia in cancer patients with postoperative pain. Clin Pharmacol Ther 1980; 28:823–6

106. Owen JA, Sitar DS, Berger L, Brownell L, Duke PC, Mitenko PA: Age-related morphine kinetics. Clin Pharmacol Ther 1983; 34:364–8

107. Egbert AM: Postoperative pain management in the frail elderly. Clin Geriatr Med 1996; 12:583–99

108. Aubrun F, Salvi N, Coriat P, Riou B: Sex- and age-related differences in morphine requirements for postoperative pain relief. ANESTHESIOLOGY 2005; 103: 156–60

109. Fillingim RB: Sex, gender, and pain: Women and men really are different. Curr Rev Pain 2000; 4:24–30

110. Barsky AJ, Peekna HM, Borus JF: Somatic symptom reporting in women and men. J Gen Intern Med 2001; 16:266–75

111. Riley JL, III, Robinson ME, Wise EA, Price DD: A meta-analytic review of pain perception across the menstrual cycle. Pain 1999; 81:225–35

112. Ciccone GK, Holdcroft A: Drugs and sex differences: A review of drugs relating to anaesthesia. BJA 1999; 82:255–65

113. Yates P, Dewar A, Edwards H, Fentiman B, Najman J, Nash R, Richardson V, Fraser J: The prevalence and perception of pain amongst hospital in-patients. J Clin Nurs 1998; 7:521–30

114. Colameco S, Becker LA, Simpson M: Sex bias in the assessment of patient complaints. J Fam Pract 1983; 16:1117–21

115. Mitra S, Sinatra RS: Perioperative management of acute pain in the opioid-dependent patient. ANESTHESIOLOGY 2004; 101:212–27

116. Perel P, Edwards P, Wentz R, Roberts I: Systematic review of prognostic models in traumatic brain injury. BMC Med Inform Decis Mak 2006; 6:38

117. Aubrun F, Valade N, Coriat P, Riou B: Predictive factors of severe postoperative pain in the postanesthesia care unit. Anesth Analg 2008; 106:1535–41

118. Pavlin DJ, Chen C, Penaloza DA, Polissar NL, Buckley FP: Pain as a factor complicating recovery and discharge after ambulatory surgery. Anesth Analg 2002; 95:627–34

119. Fraser RA, Hotz SB, Hurtig JB, Hodges SN, Moher D: The prevalence and impact of pain after day-care tubal ligation surgery. Pain 1989; 39:189–201

120. Ware JE Jr: Conceptualization and measurement of health-related quality of life: Comments on an evolving field. Arch Phys Med Rehabil 2003; 84:S43–51

121. Zakowski SG, McAllister CG, Deal M, Baum A: Stress, reactivity, and immune function in healthy men. Health Psychol 1992; 11:223–32

122. Zakowski SG, Cohen L, Hall MH, Wollman K, Baum A: Differential effects of active and passive laboratory stressors on immune function in healthy men. Int J Behav Med 1994; 1:163–84

123. Zigmond AS, Snaith RP: The hospital anxiety and depression scale. Acta Psychiatr Scand 1983; 67:361–70

124. Rockliff BW: A brief self-rating questionnaire for depression (SRQ-D). Psychosom 1969; 10:236–43

125. Dratcu L, da Costa RL, Calil HM: Depression assessment in Brazil. The first application of the Montgomery-Asberg Depression Rating Scale. Br J Psychiatry 1987; 150:797–800

126. Hamilton M: The assessment of anxiety states by rating. Br J Med Psychol 1959; 32:50–5

127. Hamilton M: A rating scale for depression. J Neurol Neurosurg Psychiatry 1960; 23:56–62

128. Brady MJ, Cella DF, Mo F, Bonomi AE, Tulsky DS, Lloyd SR, Deasy S, Cobleigh M, Shiomoto G: Reliability and validity of the Functional Assessment of Cancer Therapy-Breast quality-of-life instrument. J Clin Oncol 1997; 15:974–86

129. Barsky AJ, Wyshak G, Klerman GL: The somatosensory amplification scale and its relationship to hypochondriasis. J Psychiatr Res 1990; 24:323–34

130. Pilowsky I, Spence ND: Patterns of illness behaviour in patients with intractable pain. J Psychosom Res 1975; 19:279–87

131. Dworkin RH, Hartstein G, Rosner HL, Walther RR, Sweeney EW, Brand L: A high-risk method for studying psychosocial antecedents of chronic pain: The prospective investigation of herpes zoster. J Abnorm Psychol 1992; 101:200–5

132. Eysenck HJ: The biological basis of personality. Springfield, CC Thomas, 1967.

133. Wallston KA, Wallston BS, DeVellis R: Development of the Multidimensional Health Locus of Control (MHLC) Scales. Health Educ Monogr 1978; 6:160–70

134. Horowitz M, Wilner N, Alvarez W: Impact of event scale: A measure of subjective stress. Psychosom Med 1979; 41:209–18

135. Carver CS, Scheier MF, Weintraub JK: Assessing coping strategies: A theoretically based approach. J Pers Soc Psychol 1989; 56:267–83

136. Sullivan MJ, Thorn B, Haythornthwaite JA, Keefe F, Martin M, Bradley LA, Lefebvre JC: Theoretical perspectives on the relation between catastrophizing and pain. Clin J Pain 2001; 17:52–64

137. Cleeland CS, Ryan KM: Pain assessment: Global use of the Brief Pain Inventory. Ann Acad Med Singapore 1994; 23:129–38