Improving postoperative pain care

An Acute Pain Service data analysis

Regina van Boekel

Improving postoperative pain care

An Acute Pain Service data analysis

Regina van Boekel

The studies in this thesis have been performed at the Department of Anesthesiology, Pain and Palliative Medicine of the Radboud University Medical Center.

For reasons of consistency within this thesis, some terms have been standardized throughout the text. As a consequence the text may differ from the articles that have been published.

Financial support by Grünenthal B.V. and Eurocept B.V. for the publication of this thesis is gratefully acknowledged.

ISBN: 9789082738315

Cover photo: ZorginBeeld | Frank Muller
Layout: Mijn Proefschrift | www.mijn-proefschrift.nl
Printed by: ProefschriftMaken | www.proefschriftmaken.nl

Improving postoperative pain care:
an Acute Pain Service data analysis

Proefschrift

ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.H.J.M. van Krieken,
volgens besluit van het college van decanen
in het openbaar te verdedigen op donderdag 14 december 2017
om 14:30 uur precies

door

Regina Lamberta Maria van Boekel

geboren op 2 november 1972
te Oss, Nederland

Promotor:	Prof. dr. K.C.P. Vissers
Copromotoren:	Dr. M.A.H. Steegers Dr. R. van der Sande (HAN)
Manuscriptcommissie:	Prof. dr. J.G. van der Hoeven Prof. dr. H. Vermeulen Prof. dr. N. Rawal (Örebro Universitet, Zweden)

If you can’t explain it simply, you don’t understand it well enough.
Albert Einstein (1879-1955)

Dedicated to my family

Table of Contents

Prologue

"Why do I have to suffer so much pain? We fly to the moon, but professionals like you are not able to alleviate this pain? " (patient 1)

"Please, give me this epidural, or I will definitely get a pneumonia!" (patient 2)

"You can't expect me to know all this; if patients are in pain I will call you." (nurse to acute pain service)

"Of course he is not in pain, his pain score is 3." (resident of the surgical department)

Of all the forms of pain, postoperative pain is one of the most ubiquitous. Rarely does someone undergo a surgical procedure without suffering pain, ranging from relatively mild to overwhelmingly severe. So it would be easy to assume that we have a large body of information about postoperative pain management. A lot of research, summarized in guidelines and pain protocols on acute postoperative pain management, has been performed. I read the articles, I worked on a chapter in the new Dutch guideline on postoperative pain management, and I developed the pain protocol for my hospital according to the guidelines. However, in daily practice, I noticed that the protocols did not answer all questions about individual patients.

I have written down some quotes I have heard a lot of times, when attending my shift of the acute pain service (APS) at the Radboud university medical center. Those quotes inspired me to reflect on my knowledge and my work. Some questions were raised. For example, can patients, being treated perfectly according to the guidelines, still be in pain? How do I treat patients who claim that pain is acceptable to them, when having high pain scores. Is it true that patients who are in too much pain develop complications?
Because I work as a clinical pain nursing consultant, nurses and physicians expect me to have specialized knowledge on pain management. I like to share my knowledge and I enjoy teaching. But for me it is very difficult to explain pain issues to health professionals when these issues do not make perfect sense. For example when explaining the assessment of pain. In the Netherlands, many people regard pain scores as objective measures, with a cut-off point for treatment. Explaining that a simple pain score is not enough information to decide on pain treatment is necessary and lacking in our training programs for health professionals.

Being the coordinator of the Dutch national education for clinical pain nursing consultant, I hear many stories about acute pain service in hospitals. Students describe many different types of acute pain services in which they are employed. I noticed that we did not know anything about the acute pain services in the

Netherlands. What are tasks and responsibilities of the acute pain service? Do APS members need to advise, to take over, to teach, or to organize?

The more I knew about postoperative pain management, the more questions were raised on this topic. All these questions stimulated me to put on my own research, finally resulting in my thesis.

Rianne van Boekel

General introduction

1

Postoperative pain is a common occurrence following surgery. Severe postoperative pain increases the incidence of postoperative complications, prolongs length of stay, causes readmissions, and significantly reduces patient satisfaction and quality of life [1, 2]. In addition, it is a considerable burden on health care service costs, both directly as a result of consuming medical care, and indirectly as a result of absenteeism, less labor productivity, and increased social welfare payments [3-8].

In 2010, a total of 1,414,558 operations were performed in the Netherlands [9].
A Dutch study of 1490 surgical inpatients showed that 41 % of patients had moderate-to severe pain on the day of surgery, with almost 15 % of patients reporting moderate-to-severe pain on the fourth postoperative day [10]. In ambulatory surgery, 26 % of the patients had moderate to severe pain on the day of the operation, 21 % on day 1 following surgery, 13 % on day 2, 10 % on day 3, and 9 % on day 4 [11]. Results from other studies also suggest that postoperative pain is common, with a prevalence of moderate to severe pain varying between 47 % and 65 % [6, 12-14].

In this thesis, our focus is on postoperative pain experienced by inpatients in an academic hospital setting in the Netherlands.

Definition of pain

Pain is often the major symptom in many medical conditions and is one of the most important reasons for seeking medical assistance [15]. The internationally recognized definition by the International Association for the Study of Pain states that: “Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” [16]. McCaffrey and Beebe offer an alternative definition: “Pain is whatever the experiencing person says it is, existing whenever the experiencing person say it does” [17]. Both definitions highlight the personal experience of pain as being something greater than tissue damage triggering a response from the nervous system.

Pain can be divided in acute and chronic pain. Acute pain is defined as “pain of recent onset and probable limited duration. It usually has an identifiable temporal and causal relationship to injury or disease” [18]. Chronic pain is defined as “pain that extends beyond the expected period of healing” [16]. In both acute and chronic pain, the experience depends on multidimensional factors, with biological, psychological, societal and spiritual dimensions [19-23]. Thus, pain and the behaviors it elicits are influenced by genetics, emotions, past experience, anticipated consequences, and the environment at the time of an incident.

Acute postoperative pain is defined as “pain occurring in surgical patients following a procedure” [24]. If, after a surgical procedure, the resulting pain continues for at least two months, and other causes of the pain have been excluded [25], then this is termed chronic postoperative pain.

Physiological and psychosocial impact of postoperative pain

Studies show that adequately controlled postoperative pain contributes to the prevention of medical complications [3, 26-28]. The physiology and mechanisms of acute postoperative pain may explain this relation with medical complications. Acute postoperative pain results from inflammation due to tissue damage or/ and nerve injury. In the acute phase, postoperative pain induces the increase in the neuro-humoral stress response, which includes an increase in cortisol, catecholamines, glucagon, protein catabolism and in autonomic activity [29]. These increased responses have metabolic, hemodynamic, hemostatic, gastro-intestinal and immune related consequences [28].

At a behavioral level, common early responses are a lack of movement, lack of deep sighing, and ineffective coughing. This may result in reduced lung volume, reduced clearance of the lungs, and decreased production of surfactant of the lungs, and in the long term, in inhibition of the mobility of the patient. These behavioral responses may thus lead to postoperative motor complications and decubitus ulcers.

On a psychological level, inadequately controlled acute postoperative pain was found to increase the risk of long-term depression, 6 months after cardiac surgery [30]. Several studies have shown a strong negative relationship between pain and quality of life [13, 31]. Studies of the risk factors for developing acute postoperative pain show that genetic factors [32] and environmental factors [33] may contribute to the level of postoperative pain. Several risk factors have been identified, for example: age [33-35], gender [35, 36], Body Mass Index [37], level of preoperative pain [35, 36, 38], preoperative anxiety [35, 39], pain catastrophizing [40, 41], and type of surgery [35]. These findings may also explain why, despite adequate guidelines and execution of pain protocols, some patients do not fully respond to medical pain treatment. Another approach for patients who do not respond to usual care and keep having pain needs further study.

Quality of care in postoperative pain management

Recent initiatives by pain professionals have resulted in improvements in the quality of postoperative pain management. In order to evaluate the progress made in the field of postoperative pain management, we introduce some components of pain management theory. The Donabedian quality of care framework provides a conceptual model for evaluating quality of health care issues. In the framework, information from which inferences can be drawn about the quality of care is classified under three categories: “structure,” “process,” and “outcome” [42]. Structure describes the context in which care is delivered, including acute pain services. Process denotes the transactions between patients and providers throughout the delivery of healthcare, including pain assessments and the adherence to guidelines

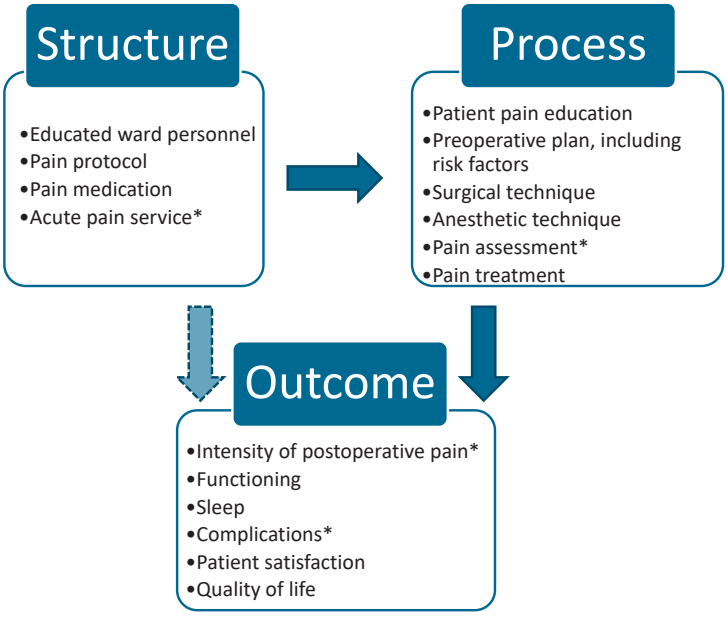

Figure 1 Donabedian's quality of care framework of postoperative pain
Donabedian's quality of care framework of postoperative pain management shows the multifactorial factors responsible for the quality of pain management after surgery, classified under three categories "structure", "process", and "outcome". The factors indicated with * are addressed in this thesis.

or protocols, as well as the use of digital registration tools. Finally, outcome refers to the effects of healthcare on the health status of patients, such as complications after surgery. Preexisting knowledge about the linkage between these categories for postoperative pain management is well known [3, 14, 43]. (see Figure 1)

In Figure 1, the quality cycle of postoperative pain management is explained. The context (structure) in which postoperative pain care is delivered affects the processes and outcomes. For example, if a comprehensive pain protocol is not available or the ward personnel do not know what should be done for a patient in pain, the pain will not be assessed and consequently may be inadequately treated. Outcomes indicate the combined effects of structure and process, which in this example may result in a patient with unacceptably high pain levels, decreased quality of life, or a pain-related complication.
This model serves as a framework for preventing problems related to quality and, should problems still arise, to help improve the quality of care. As only those factors related to structure and process can be manipulated, to improve the outcome, deficiencies can only be corrected by system redesigns and other process inputs. In this thesis, a number of the factors described in each of the three categories will be addressed; Acute Pain Service (APS), pain assessment, intensity of pain and complications. In this way, the Donabedian model is used to evaluate several

quality improving innovations in postoperative pain management [42].

Acute pain service

In the Donabedian model, structural factors such as acute pain services are discussed first. To improve the management of postoperative pain, several hospitals in the Netherlands have initiated an APS. The APS is a dedicated and specialized team of pain specialists and nurses who support and advise on the safety and the effectiveness of acute pain management in a hospital; especially regarding postoperative pain [44-46]. In general its goal is to improve postoperative pain management, to mentor complex pain patients, facilitate a possible reduction in postoperative nausea and vomiting, prevent the development of side effects, increase patient wellbeing, and reduce hospital stay [45, 47-53].
The concept of a structural APS was first noted by Ready in 1988 as an anesthesiology-based postoperative pain management service [54], although in 1976, an anonymous editorial on the creation of analgesia-providing teams had been published in Anaesthesia and Intensive Care.
In the Netherlands, the need for an APS team to improve quality of postoperative pain management was first described in 1994 [55]. In 1991, the Radboud university medical center had already introduced an acute pain protocol and started up a pain service run by anesthesiologists and nurses. Seventeen years later in 2008, the pain service was formally adapted to a nurse-based anesthesiologist-supervised APS [56]. The nurse-based anesthesiologist-supervised APS model was chosen for several reasons. APS nurses are familiar with the wards, are recognizable and easy accessible for ward nurses, and have an affinity with nurses and their routines. This in contrast to residents, who often change positions because of their training. APS nurses thus show continuity, competency and knowledge of practical resources [56]. In addition, compared to involving anesthesiologists or residents, a nurse-based APS is cost-effective [49].
In this type of APS, several healthcare professionals work closely together to deliver the best postoperative pain care. APS nurses standardly visit postoperative patients in (high risk of) pain, do consultations, anticipate patient needs and are always available. On average, patients are seen by the APS nurses for three days after surgery and are available to ward nurses or physicians for consultation in complex postoperative situations. If the APS nurses need advice on complex patients, they can contact the supervising anesthesiologist. In addition to patient-related activities, the APS nurses perform several important non-patient-related activities like education, research and quality improvement, as well as evaluating pain scores and making protocol adjustments [44, 46, 50, 51, 57-59].

Studies show that there is considerable variation in the organization and procedures of APS teams in hospitals [44, 60-62]. Some APS teams restrict their activities to the management of patients after major surgery, others visit all postoperative patients or consult chronic pain patients as well. Not all APS teams perform

non-patient-related activities.
Currently there is no consensus about what constitutes a good APS with respect to standards for staffing, facilities needed, and procedures [58]. In the Netherlands we do not know how many Dutch hospitals have an APS, and where they exist, how the APS is staffed, educated and organized.

Adherence to pain guidelines

Process analysis is the next step in the Donabedian quality improvement model. The complex nature of acute postoperative pain and its management resulted in the development of clinical practice guidelines to promote evidence-based, effective, and safe postoperative pain assessment and management programs/strategies [63]. In 2010, the Dutch Hospital Patient Safety Program was implemented in almost all Dutch Hospitals. The program provides practice guidelines on pain assessment and pain treatment [64]. It states that pain should be assessed at least every eight hours, based on the usual working hours of a nursing shift, and that it should be rated using a standardized numerical rating scale [65] and documented in the patient's medical record; if the pain score is greater than three, then pain should be treated [64]. In 2012, the Dutch Society of Anesthesiology updated the Dutch guidelines for postoperative pain management [66, 67], thus providing evidence-based standards for postoperative pain assessment, pain treatment and acute pain service.

An important measure to improve the process of postoperative pain management is the systematic and standardized assessment of postoperative pain [68]. Patient self-report is the primary source of all pain assessments, as pain is inherently subjective [63]. Differences have been identified between nurses' assessments of patients' pain and patients' self-assessments, with nurses giving consistently lower ratings than patients [69, 70]. Studies report that compliance among doctors and nurses with respect to the systematic assessment of pain is still suboptimal [71] and show that it slowly deteriorates after an education program [72].

Limited information is available about the factors influencing compliance with the guidelines for pain assessments [71, 73-75]. No studies were performed in the Netherlands following the implementation of the Dutch Hospital Patient Safety Program in 2010. It remains unclear whether pain is regularly assessed in Dutch hospitals and if the presence of an APS in the hospital influences adherence to these guidelines.

Standardized digital administration tools for pain data

Quality measurement is fundamental to the systematic improvement of health care [42, 76]. In clinical practice, documenting pain assessments and treatments is essential in order to communicate patient status between different and successive health professionals, such as nurses on daily shifts [77]. At an individual patient level,

documenting pain scores several times each day can clarify the success or failure of pain treatment and the need for adjustment of pain therapy. At group level, documented data of pain assessments is needed for analysis, to identify barriers in optimal pain management, and to promote quality improvement [78-80]. In addition, patient data is needed to identify risk factors and to develop procedures for the optimal prevention of postoperative pain [35].
To reduce workload and minimize the need for special research teams, data collection should be organized efficiently, accurately and reliably. Ideally, data collection should be automatically connected with clinical practice. Improved digital administration will lead to the creation of the 'big data' sets required to create an adequate prediction rule for whether or not a patient will be in pain after surgery [34].

Postoperative pain and the prevention of complications after surgery

The final phase of the Donabedian model describes outcome such as complications after surgery. In the past twenty-five years, many reports of inadequate management of acute postoperative pain have highlighted the humanitarian need to keep patients comfortable and to prevent complications and adverse effects [1, 2].

Inadequate management of postoperative pain, whether undertreatment or overtreatment, is considered to have negative consequences for patients resulting, for example, in cardiac alterations, myocardial ischemia or infarction, thrombo-embolic and pulmonary complications, immune alterations, impaired rehabilitation, increased length of stay and/or hospital readmission, decreased quality of life, and adverse events related to excessive analgesic use [13, 43]. Additionally, acute postoperative pain plays an important, yet not fully understood, role in the development of chronic postoperative pain [81, 82]. Overall, postoperative complications lead to an increase in resource utilization which in turn leads to higher healthcare costs [7, 8].

Currently, there is a lack of scientific evidence for and consensus on the effects of adequate acute postoperative pain management on postoperative outcome [83]. We postulate that the provision of high-quality postoperative analgesia may reduce the development of major postoperative complications. To study this, due to the relatively low incidence of major postoperative morbidity, large patient numbers in any individual clinical trial are needed.

Pain scores and complications

In 2000, the Joint Commission, an independent organization for accrediting and certifying health care organizations and programs in the United States, declared pain as the "fifth vital sign", emphasizing that a pain score of less than 4/10 should

be achieved for all patients. Since then, routine pain assessment and treatment has led to an increased incidence of opioid-related adverse drug events, such as over-sedation and respiratory depression [14, 83, 84].
Similarly in the Netherlands, the Dutch Hospital Patient Safety Program Practice Guideline for (postoperative) pain management suggested a score of >3 on the numerical rating scale (NRS) as a cut-off for pain treatment. Recent Dutch studies have shown, however, that patients and caregivers interpret pain intensity scores differently [85]. Patients may choose not to take more analgesics because they interpret their pain as "bearable" [86, 87]. Another study stressed the difference between pain at rest and movement-evoked pain [88]. Thus, using a firm cut-off score alone as a measure for pain treatment may be dangerous; other outcome measures such as the patient's opinion on the acceptability of the pain should be included [89]. The relationships between patients' postoperative pain scores and their willingness to accept pain, as well as their performance of physical activities has not yet been investigated. In addition, whether or not there is a relationship between the acceptability of the pain and the development of postoperative complications also remains unclear.

Societal impact of acute postoperative pain

Because of the importance and high prevalence of postoperative pain, the Dutch Health Care Inspectorate, the organization that monitors health care quality and safety in the Netherlands, has taken actions to support adequate pain management [90]. In 2003, quality indicators for postoperative pain management were added to the basic set of hospital quality indicators. The Inspectorate considers pain assessment a prerequisite for adequate pain management: only a few patients should have high postoperative pain scores, and all hospitals should have an acute pain service. Therefore, the indicators included a structure indicator, i.e. does the hospital have an APS, a process indicator, i.e. the percentage of postoperative patients with a standardized pain measurement, as well as outcome indicators, i.e. the percentage of postoperative patients with a pain score > 4 and subsequently the percentage of postoperative patients with a pain score > 7.

In the Netherlands, the national Hospital Patient Safety Program was launched in 2010 and the "early recognition and treatment of pain" was one of the themes implemented [64]. The program is a part of the safety management system (SMS, or VMS in Dutch) which embeds patient safety in healthcare practice. Hospitals use the SMS to continuously identify risks, implement improvements, and establish, evaluate and modify policy.

Research methodology

Literature on improving postoperative pain management is mostly based on

a commonly used approach for measuring the impact of implementing an APS, the 'uncontrolled before-after study' [50]. However, this type of study tends to overestimate the effects of the treatment or the services under study and datasets are often small. The selection bias of before-after comparisons on this topic may therefore be great and most studies are not run long enough to determine whether the intervention and its apparent effect are sustainable. Due to these concerns, the Cochrane Effective Practice and Organization of Care (EPOC) Group strongly discourages the inclusion of uncontrolled before-after studies in EPO reviews because it is difficult, if not impossible, to attribute their causation [91].

Alternative methods, such as cluster randomization, have been successful in other studies on health system interventions [92]. Randomization minimizes selection bias and a randomized controlled trial (RCT) is therefore often considered to be the gold standard. However, trial participants typically do not represent the complete population as they are preselected. Additionally, study protocols do not always reflect clinical practice. Therefore, results from RCTs may not apply in a more general population as in a randomized population it is not always possible to discriminate which subgroup of participants actually benefited from the intervention being studied and mean scores are not always predictive of individual results [93, 94]. By creating subgroups, researchers can determine which patients with a certain profile possessing certain characteristics will respond to a specific treatment or not. In order to be able to draw conclusions, subgroups have to be of a sufficient magnitude to generate large datasets [34, 35, 95]. These large datasets should be created in the clinical process to avoid high costs and workload. Large prospective observational studies resulting in clinically collected data are therefore needed in order to answer research questions on the quality of postoperative pain management.

Implementation studies often end when the first phases of implementation are completed. This often reduces the attention paid to the process and newly established practices [77]. In clinical practice, new initiatives need to settle in so that users are able to familiarize themselves with the new interventions. Regular incentives help users to remember the newly learned actions, and periodic evaluation is valuable to identify both barriers and facilitators following the implementation of the new intervention.

Aim of the thesis

Inadequate postoperative pain management is associated with several negative consequences, patient discomfort, and is linked to increased healthcare costs. The overall aim of this thesis is to explore the quality of postoperative pain management in hospitals. We used the Donabedian model to assess the quality of postoperative pain management, selecting a set of factors from each of the three categories: structure, process and outcome [42]. The following research questions

were formulated for each category:

The organizational **structure** of pain management in hospitals:

1. How many APS services are available in Dutch hospitals, what is their structure and what responsibilities are delineated?

The **process** of pain assessment in hospitals:

2. Compliance with pain assessment in postoperative patients after implementation of the Dutch Hospital Patient Safety Program:
    a. What is the compliance with pain assessment in postoperative patients after implementation of the Dutch Hospital Patient Safety Program, from the viewpoint of the hospitals?
    b. What is the compliance with pain assessment in postoperative patients after implementation of the Dutch Hospital Patient Safety Program, based on patient records.
    c. Which factors influence the actual compliance with pain assessment in postoperative patients after implementation of the Dutch Hospital Patient Safety Program?

The **outcome** of postoperative pain management in hospitals:

3. The outcome of postoperative pain management in the Dutch Radboud university medical center:
    a. What is the prevalence of moderate to severe acute postoperative pain in hospital patients?
    b. Do neuraxial or regional analgesia provide superior pain relief compared with patient-controlled intravenous analgesia in three different procedures, based on data from the Acute Pain Service?
    c. What are the differences in values for pain measures, such as a numerical pain score, an acceptability score, and a physical functioning score?
    d. Is there an association between unacceptable postoperative pain and complications after surgery?

Outline of the thesis

The thesis is organized in three main parts based on the three factors of Donabedian's framework for modelling the quality of care: structure, process and outcome.
In Chapter 2, the first part of the thesis, we answer research question 1. We present a detailed report on the current state, structure and responsibilities of the APS teams in Dutch hospitals. We also answer question 2a by providing an overview of the "pain theme" of the Dutch Hospital Patient Safety Program and reports from Dutch hospitals on this theme.
In Chapter 3, the second part of the thesis, we review the process of postoperative pain management. We compare data collected in a national survey on the pain assessment compliance of health professionals in Dutch hospitals with the assessments documented in patient records, thus answering question 2b. We then provide an analysis of the association between this compliance and hospital and

APS characteristics, answering question 2c.
In Chapter 4, starting the third part of the thesis, we answer the questions related to the outcomes of postoperative pain management. We first describe the prevalence of moderate to severe acute postoperative pain in patients who underwent major surgery, using a large dataset of clinically collected APS data, thereby answering question 3a. In addition, we compare epidural regional analgesia versus patient-controlled intravenous analgesia on pain scores, answering question 3b. In Chapter 5, we answer question 3c by describing the relationships between different pain measures, such as a numerical pain score, an acceptability score, and a physical functioning score, as well as a cut-off score for pain treatment.
In Chapter 6, we report on the prevalence of moderate to severe acute postoperative pain of surgical patients undergoing all kinds of surgery, thereby adding to the prevalence data resulting from question 3a. We also investigate the association between unacceptable postoperative pain and complications after surgery, answering question 3d. Finally, in Chapter 7, the discussion and conclusions, we summarize our findings in relation to the current situation regarding postoperative pain care, providing directions for future research.

References

1. Peters CL, Shirley B, Erickson J. The effect of a new multimodal perioperative anesthetic regimen on postoperative pain, side effects, rehabilitation, and length of hospital stay after total joint arthroplasty. The Journal of arthroplasty. 2006;21(6 Suppl 2):132-8.
2. Regenbogen SE, Mullard AJ, Peters N, Brooks S, Englesbe MJ, Campbell DA, Jr., et al. Hospital Analgesia Practices and Patient-reported Pain After Colorectal Resection. Annals of surgery. 2016;264(6):1044-50.
3. Meissner W, Coluzzi F, Fletcher D, Huygen F, Morlion B, Neugebauer E, et al. Improving the management of post-operative acute pain: priorities for change. Current medical research and opinion. 2015;31(11):2131-43.
4. Zimberg SE. Reducing pain and costs with innovative postoperative pain management. Managed care quarterly. 2003;11(1):34-6.
5. Morrison RS, Magaziner J, McLaughlin MA, Orosz G, Silberzweig SB, Koval KJ, et al. The impact of post-operative pain on outcomes following hip fracture. Pain. 2003;103(3):303-11.
6. Apfelbaum JL, Chen C, Mehta SS, Gan TJ. Postoperative pain experience: results from a national survey suggest postoperative pain continues to be undermanaged. Anesthesia and analgesia. 2003;97(2):534-40, table of contents.
7. Zoucas E, Lydrup ML. Hospital costs associated with surgical morbidity after elective colorectal procedures: a retrospective observational cohort study in 530 patients. Patient safety in surgery. 2014;8(1):2.
8. Encinosa WE, Hellinger FJ. The impact of medical errors on ninety-day costs and outcomes: an examination of surgical patients. Health services research. 2008;43(6):2067-85.
9. Centraal Bureau voor de Statistiek. Operaties in het ziekenhuis: soort opname, leeftijd en geslacht, 1995-2010. 2014 [cited 2016 Novembre 2]. Available from: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=80386NED&D1=a&D2=a&D3=0,2-5&D4=a&D5=l&HDR=T&STB=G4,G1,G2,G3&VW=T
10. Sommer M, de Rijke JM, van Kleef M, Kessels AG, Peters ML, Geurts JW, et al. The prevalence of postoperative pain in a sample of 1490 surgical inpatients. European journal of anaesthesiology. 2008;25(4):267-74.
11. Gramke HF, de Rijke JM, van Kleef M, Raps F, Kessels AG, Peters ML, et al. The prevalence of postoperative pain in a cross-sectional group of patients after day-case surgery in a university hospital. The Clinical journal of pain. 2007;23(6):543-8.
12. Dolin SJ, Cashman JN, Bland JM. Effectiveness of acute postoperative pain management: I. Evidence from published data. British journal of anaesthesia. 2002;89(3):409-23.
13. Wu CL, Naqibuddin M, Rowlingson AJ, Lietman SA, Jermyn RM, Fleisher LA. The effect of pain on health-related quality of life in the immediate postoperative period. Anesthesia and analgesia. 2003;97(4):1078-85, table of contents.
14. Wu CL, Raja SN. Treatment of acute postoperative pain. Lancet. 2011;377(9784):2215-25.
15. Radnovich R, Chapman CR, Gudin JA, Panchal SJ, Webster LR, Pergolizzi JV, Jr. Acute pain: effective management requires comprehensive assessment. Postgraduate medicine. 2014;126(4):59-72.
16. Merskey H, Bogduk N. Classification of chronic pain. Part III: Pain Terms, A Current List with Definitions and Notes on Usage. Report by the International Association for the Study of Pain Task Force on Taxonomy. Seattle: IASP Press, 1994.
17. McCaffery M. Nursing practice theories related to cognition, bodily pain and man-environmental interactions, Los Angeles, CA: 1968. UCLA Students Store.
18. LB R, WT E. Management of Acute Pain: A Practical Guide. Report of the International Association for the Study of PainTask Force on Acute Pain Seattle: IASP Press, 1992.
19. Fishman SM, Young HM, Lucas Arwood E, Chou R, Herr K, Murinson BB, et al. Core competencies for pain management: results of an interprofessional consensus summit. Pain medicine. 2013;14(7):971-81.
20. Dworkin RH, Bruehl S, Fillingim RB, Loeser JD, Terman GW, Turk DC. Multidimensional Diagnostic Criteria for Chronic Pain: Introduction

to the ACTTION-American Pain Society Pain Taxonomy (AAPT). J Pain. 2016;17(9 Suppl):T1-9.
21. Gatchel RJ, Peng YB, Peters ML, Fuchs PN, Turk DC. The biopsychosocial approach to chronic pain: scientific advances and future directions. Psychological bulletin. 2007;133(4):581-624.
22. Wachholtz AB, Pearce MJ, Koenig H. Exploring the relationship between spirituality, coping, and pain. Journal of behavioral medicine. 2007;30(4):311-8.
23. Loeser JD. Pain and suffering. The Clinical journal of pain. 2000;16(2 Suppl):S2-6.
24. American Society of Anesthesiologists Task Force on Acute Pain M. Practice guidelines for acute pain management in the perioperative setting: an updated report by the American Society of Anesthesiologists Task Force on Acute Pain Management. Anesthesiology. 2012;116(2):248-73.
25. Macrae WA. Chronic pain after surgery. British journal of anaesthesia. 2001;87(1):88-98.
26. Sharrock NE, Cazan MG, Hargett MJ, Williams-Russo P, Wilson PD, Jr. Changes in mortality after total hip and knee arthroplasty over a ten-year period. Anesthesia and analgesia. 1995;80(2):242-8.
27. Katz J, Jackson M, Kavanagh BP, Sandler AN. Acute pain after thoracic surgery predicts long-term post-thoracotomy pain. The Clinical journal of pain. 1996;12(1):50-5.
28. Kehlet H, Holte K. Effect of postoperative analgesia on surgical outcome. British journal of anaesthesia. 2001;87(1):62-72.
29. Kehlet H. Surgical stress: the role of pain and analgesia. British journal of anaesthesia. 1989;63(2):189-95.
30. Royse C, Remedios C, Royse A. High thoracic epidural analgesia reduces the risk of long-term depression in patients undergoing coronary artery bypass surgery. Annals of thoracic and cardiovascular surgery : official journal of the Association of Thoracic and Cardiovascular Surgeons of Asia. 2007;13(1):32-5.
31. Taylor RS, Ullrich K, Regan S, Broussard C, Schwenkglenks M, Taylor RJ, et al. The impact of early postoperative pain on health-related quality of life. Pain practice : the official journal of World Institute of Pain. 2013;13(7):515-23.
32. Sia AT, Lim Y, Lim EC, Goh RW, Law HY, Landau R, et al. A118G single nucleotide polymorphism of human mu-opioid receptor gene influences pain perception and patient-controlled intravenous morphine consumption after intrathecal morphine for postcesarean analgesia. Anesthesiology. 2008;109(3):520-6.
33. Gerbershagen HJ, Pogatzki-Zahn E, Aduckathil S, Peelen LM, Kappen TH, van Wijck AJ, et al. Procedure-specific risk factor analysis for the development of severe postoperative pain. Anesthesiology. 2014;120(5):1237-45.
34. Janssen KJ, Kalkman CJ, Grobbee DE, Bonsel GJ, Moons KG, Vergouwe Y. The risk of severe postoperative pain: modification and validation of a clinical prediction rule. Anesthesia and analgesia. 2008;107(4):1330-9.
35. Kalkman CJ, Visser K, Moen J, Bonsel GJ, Grobbee DE, Moons KG. Preoperative prediction of severe postoperative pain. Pain. 2003;105(3):415-23.
36. Pinto PR, McIntyre T, Almeida A, Araujo-Soares V. The mediating role of pain catastrophizing in the relationship between presurgical anxiety and acute postsurgical pain after hysterectomy. Pain. 2012;153(1):218-26.
37. Massaron S, Bona S, Fumagalli U, Battafarano F, Elmore U, Rosati R. Analysis of post-surgical pain after inguinal hernia repair: a prospective study of 1,440 operations. Hernia. 2007;11(6):517-25.
38. 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(2-3):177-85.
39. Katz J, Poleshuck EL, Andrus CH, Hogan LA, Jung BF, Kulick DI, et al. Risk factors for acute pain and its persistence following breast cancer surgery. Pain. 2005;119(1-3):16-25.
40. Papaioannou M, Skapinakis P, Damigos D, Mavreas V, Broumas G, Palgimesi A. The role of catastrophizing in the prediction of postoperative pain. Pain medicine. 2009;10(8):1452-9.
41. Khan RS, Ahmed K, Blakeway E, Skapinakis P, Nihoyannopoulos L, Macleod K, et al. Catastrophizing: a predictive factor for postoperative pain. American journal of surgery. 2011;201(1):122-31.
42. Donabedian A. The quality of care. How can it be assessed? JAMA. 1988;260(12):1743-8.
43. Argoff CE. Recent management advances

in acute postoperative pain. Pain practice : the official journal of World Institute of Pain. 2014;14(5):477-87.
44. Rawal N. Organization, function, and implementation of acute pain service. Anesthesiology clinics of North America. 2005;23(1):211-25.
45. Werner MU, Soholm L, Rotboll-Nielsen P, Kehlet H. Does an acute pain service improve postoperative outcome? Anesthesia and analgesia. 2002;95(5):1361-72, table of contents.
46. Breivik H. How to implement an acute pain service. Best practice & research Clinical anaesthesiology. 2002;16(4):527-47.
47. Miaskowski C, Crews J, Ready LB, Paul SM, Ginsberg B. Anesthesia-based pain services improve the quality of postoperative pain management. Pain. 1999;80(1-2):23-9.
48. Sartain JB, Barry JJ. The impact of an acute pain service on postoperative pain management. Anaesthesia and intensive care. 1999;27(4):375-80.
49. Stadler M, Schlander M, Braeckman M, Nguyen T, Boogaerts JG. A cost-utility and cost-effectiveness analysis of an acute pain service. Journal of clinical anesthesia. 2004;16(3):159-67.
50. Bardiau FM, Taviaux NF, Albert A, Boogaerts JG, Stadler M. An intervention study to enhance postoperative pain management. Anesthesia and analgesia. 2003;96(1):179-85, table of contents.
51. Harmer M, Davies KA. The effect of education, assessment and a standardised prescription on postoperative pain management. The value of clinical audit in the establishment of acute pain services. Anaesthesia. 1998;53(5):424-30.
52. Story DA, Shelton AC, Poustie SJ, Colin-Thome NJ, McIntyre RE, McNicol PL. Effect of an anaesthesia department led critical care outreach and acute pain service on postoperative serious adverse events. Anaesthesia. 2006;61(1):24-8.
53. Frigon C, Loetwiriyakul W, Ranger M, Otis A. An acute pain service improves postoperative pain management for children undergoing selective dorsal rhizotomy. Paediatric anaesthesia. 2009;19(12):1213-9.
54. Ready LB, Oden R, Chadwick HS, Benedetti C, Rooke GA, Caplan R, et al. Development of an anesthesiology-based postoperative pain management service. Anesthesiology. 1988;68(1):100-6.
55. van den Nieuwenhuyzen MC, Janss RA, Brand R, van Kleef JW. [Postoperative pain control in The Netherlands]. Nederlands tijdschrift voor geneeskunde. 1994;138(18):902-6.
56. Rawal N, Berggren L. Organization of acute pain services: a low-cost model. Pain. 1994;57(1):117-23.
57. Shapiro A, Zohar E, Kantor M, Memrod J, Fredman B. Establishing a nurse-based, anesthesiologist-supervised inpatient acute pain service: experience of 4,617 patients. Journal of clinical anesthesia. 2004;16(6):415-20.
58. Rawal N. Acute pain services revisited--good from far, far from good? Regional anesthesia and pain medicine. 2002;27(2):117-21.
59. Karlsten R, Strom K, Gunningberg L. Improving assessment of postoperative pain in surgical wards by education and training. Quality & safety in health care. 2005;14(5):332-5.
60. Nasir D, Howard JE, Joshi GP, Hill GE. A survey of acute pain service structure and function in United States hospitals. Pain research and treatment. 2011;2011:934932.
61. Powell AE, Davies HT, Bannister J, Macrae WA. Rhetoric and reality on acute pain services in the UK: a national postal questionnaire survey. British journal of anaesthesia. 2004;92(5):689-93.
62. Stamer UM, Mpasios N, Stuber F, Maier C. A survey of acute pain services in Germany and a discussion of international survey data. Regional anesthesia and pain medicine. 2002;27(2):125-31.
63. Chou R, Gordon DB, de Leon-Casasola OA, Rosenberg JM, Bickler S, Brennan T, et al. Management of Postoperative Pain: A Clinical Practice Guideline From the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. The journal of pain : official journal of the American Pain Society. 2016;17(2):131-57.
64. Dutch Hospital Patient Safety Program. Practical Guide Pain. The Hague. 2009; [cited 2011 May 18]. Available from: http://www.vmszorg.nl/themas/pijn.
65. Breivik H, Borchgrevink PC, Allen SM, Rosseland LA, Romundstad L, Hals EK, et al. Assessment of pain. British journal of anaesthesia.

2008;101(1):17-24.
66. NVA. Richtlijn Postoperatieve pijn. Uitgave van Nederlandse Vereniging voor Anesthesiologie. Utrecht.2012 [cited 23 januari 2017]. Available from: http://www.anesthesiologie.nl/uploads/kwaliteit/Def_RL_Postoperatieve_pijn.pdf/.
67. Houweling PL, Molag ML, van Boekel RL, Verbrugge SJ, van Haelst IM, Hollmann MW. ['Postoperative pain treatment' practice guideline revised]. Nederlands tijdschrift voor geneeskunde. 2013;157(49):A7005.
68. Dihle A, Bjolseth G, Helseth S. The gap between saying and doing in postoperative pain management. Journal of clinical nursing. 2006;15(4):469-79.
69. Gunningberg L, Idvall E. The quality of postoperative pain management from the perspectives of patients, nurses and patient records. Journal of nursing management. 2007;15(7):756-66.
70. Sloman R, Rosen G, Rom M, Shir Y. Nurses' assessment of pain in surgical patients. Journal of advanced nursing. 2005;52(2):125-32.
71. Ista E, van Dijk M, van Achterberg T. Do implementation strategies increase adherence to pain assessment in hospitals? A systematic review. International journal of nursing studies. 2013;50(4):552-68.
72. De Rond M, de Wit R, van Dam F. The implementation of a Pain Monitoring Programme for nurses in daily clinical practice: results of a follow-up study in five hospitals. Journal of advanced nursing. 2001;35(4):590-8.
73. Berben SA, Meijs TH, van Grunsven PM, Schoonhoven L, van Achterberg T. Facilitators and barriers in pain management for trauma patients in the chain of emergency care. Injury. 2012;43(9):1397-402.
74. Carlson CL. Prior conditions influencing nurses' decisions to adopt evidence-based postoperative pain assessment practices. Pain management nursing : official journal of the American Society of Pain Management Nurses. 2010;11(4):245-58.
75. Czarnecki ML, Simon K, Thompson JJ, Armus CL, Hanson TC, Berg KA, et al. Barriers to pediatric pain management: a nursing perspective. Pain management nursing : official journal of the American Society of Pain Management Nurses. 2011;12(3):154-62.
76. Burstin H. The journey to electronic performance measurement. Annals of internal medicine. 2013;158(2):131-2.
77. de Rond M, de Wit R, van Dam F. The implementation of a Pain Monitoring Programme for nurses in daily clinical practice: results of a follow-up study in five hospitals. Journal of advanced nursing. 2001;35(4):590-8.
78. Duncan F, Day R, Haigh C, Gill S, Nightingale J, O'Neill O, et al. First steps toward understanding the variability in acute pain service provision and the quality of pain relief in everyday practice across the United Kingdom. Pain medicine. 2014;15(1):142-53.
79. Rothaug J, Zaslansky R, Schwenkglenks M, Komann M, Allvin R, Backstrom R, et al. Patients' perception of postoperative pain management: validation of the International Pain Outcomes (IPO) questionnaire. The journal of pain : official journal of the American Pain Society. 2013;14(11):1361-70.
80. Meissner W, Ullrich K, Zwacka S. Benchmarking as a tool of continuous quality improvement in postoperative pain management. European journal of anaesthesiology. 2006;23(2):142-8.
81. Kehlet H, Jensen TS, Woolf CJ. Persistent postsurgical pain: risk factors and prevention. Lancet. 2006;367(9522):1618-25.
82. Flor H. Psychological pain interventions and neurophysiology: implications for a mechanism-based approach. The American psychologist. 2014;69(2):188-96.
83. Frasco PE, Sprung J, Trentman TL. The impact of the joint commission for accreditation of healthcare organizations pain initiative on perioperative opiate consumption and recovery room length of stay. Anesthesia and analgesia. 2005;100(1):162-8.
84. Vila H, Jr., Smith RA, Augustyniak MJ, Nagi PA, Soto RG, Ross TW, et al. The efficacy and safety of pain management before and after implementation of hospital-wide pain management standards: is patient safety compromised by treatment based solely on numerical pain ratings? Anesthesia and analgesia. 2005;101(2):474-80, table of contents.
85. van Dijk JF, van Wijck AJ, Kappen TH, Peelen LM, Kalkman CJ, Schuurmans MJ. Postoperative pain assessment based on numeric ratings is not the same for patients and professionals: a cross-sectional study. International journal of nursing studies. 2012;49(1):65-71.
86. Harting B, Johnson T, Abrams R, Odwazny R, Hasler S, McNutt R, et al. An exploratory

analysis of the correlation of pain scores, patient satisfaction with relief from pain, and a new measure of pain control on the total dose of opioids in pain care. Quality management in health care. 2013;22(4):322-6.
87. van Dijk JF, Kappen TH, Schuurmans MJ, van Wijck AJ. The Relation Between Patients' NRS Pain Scores and Their Desire for Additional Opioids after Surgery. Pain practice : the official journal of World Institute of Pain. 2015;15(7):604-9.
88. Srikandarajah S, Gilron I. Systematic review of movement-evoked pain versus pain at rest in postsurgical clinical trials and meta-analyses: a fundamental distinction requiring standardized measurement. Pain. 2011;152(8):1734-9.
89. Maroney CL, Litke A, Fischberg D, Moore C, Morrison RS. Acceptability of severe pain among hospitalized adults. Journal of palliative medicine. 2004;7(3):443-50.
90. Dutch Health Care Inspectorate. Basic set for quality indicators for hospitals 2014 [cited 2015 18 May]. Available from: www.ziekenhuizentransparant.nl.
91. Care EPaOo, (EPOC). EPOC Resources for review authors Oslo: Norwegian Knowledge Centre for the Health Services; 2014 [cited March 13th 2017]. Available from: http://epoc.cochrane.org/cochrane-resources.
92. Ferri M, De Luca A, Giorgi Rossi P, Lori G, Guasticchi G. Does a pre-hospital emergency pathway improve early diagnosis and referral in suspected stroke patients?--Study protocol of a cluster randomised trial [ISRCTN41456865]. BMC health services research. 2005;5:66.
93. Dionne RA, Bartoshuk L, Mogil J, Witter J. Individual responder analyses for pain: does one pain scale fit all? Trends in pharmacological sciences. 2005;26(3):125-30.
94. Cappelleri JC, Bushmakin AG, Zlateva G, Sadosky A. Pain responder analysis: use of area under the curve to enhance interpretation of clinical trial results. Pain practice : the official journal of World Institute of Pain. 2009;9(5):348-53.
95. Gerbershagen HJ, Aduckathil S, van Wijck AJ, Peelen LM, Kalkman CJ, Meissner W. Pain intensity on the first day after surgery: a prospective cohort study comparing 179 surgical procedures. Anesthesiology. 2013;118(4):934-44.

Part I

Quality of postoperative pain care: structure

Acute Pain Services and Postsurgical Pain Management in the Netherlands: A Survey

2

Pain Practice 2015, 15(5): 447-454

Regina L.M. van Boekel
Monique A.H. Steegers
Inge Verbeek-van Noord
Rob van der Sande
Kris C.P. Vissers

Abstract

Background: Acute postoperative pain is still inadequately managed, despite the presence of acute pain services (APS teams). This study aimed to investigate the existence, structure, and responsibilities of Dutch APS teams and to review the implementation of the Dutch Hospital Patient Safety Program (DHPSP).

Methods: Information was gathered by a digital questionnaire, sent to all 96 Dutch hospitals performing surgical procedures.

Results: Completed questionnaires were received from 80 hospitals (83 %), of which 90 % have an APS. Important duties of the APS are regular patient rounds, checking complex pain techniques (100 %), supporting quality improvement of pain management (87 %), pain education (100 %), and pain research (21 %). Concerning implementation of the DHPSP, we found that regular in-hospital pain training is not provided in 46 % of the hospitals. Thirteen percent of the hospitals offer no patient information about pain management.

Conclusions: Almost all hospitals have an APS. They differ in both the way they are locally organized, along with the activities they employ. Future research needs to compare the effect of patient-related and non-patient-related activities of APS teams on outcomes related to pain management.

Volledig artikel in te zien via:
https://www.ncbi.nlm.nih.gov/pubmed/24661319

Part II

Quality of postoperative pain care: process

Postoperative pain assessment in hospitalized patients: national survey and secondary data analysis

3

International Journal of Nursing Studies 2016,
63: 124–131

Rianne L.M. van Boekel*
Janneke Hoogervorst-Schilp*
Carolien A. de Blok
Monique A.H. Steegers
Peter M.M. Spreeuwenberg
Cordula Wagner
* Both authors are the joint first authors on the manuscript

Abstract

Background: Measuring pain is important for the adequate pain management of postoperative patients. The actual compliance with pain assessment in postoperative patients after implementation of a national safety program is unknown.

Objectives: The aim of this study is to examine the compliance with pain assessment in postoperative patients after implementation of a national safety program, according to the national quality indicators for pain assessment in postoperative patients. Furthermore, organizational factors associated with this compliance were determined.

Study design: In this study, two data sources were used: 1) data from an evaluation study of the Dutch Hospital Patient Safety Program; and 2) data from a questionnaire survey.

Methods: The compliance with two different pain process indicators was determined: 1) 3 pain measurements a day, all three full days after surgery; and 2) ≥1 pain measurement a day, all three full days after surgery. Multilevel logistic regression analysis was used to investigate the association between organizational factors in hospitals and compliance with pain process indicators.

Results: Data of 3,895 patient records from 16 hospitals was included in this study. In 12 % of the postoperative patients, pain was measured 3 times a day, all three full days after surgery. In 53 % of the postoperative patients, pain was measured ≥1 time a day, all three full days after surgery. Compliance was highest in general hospitals compared to tertiary teaching and academic hospitals, and was statistically significantly higher at the surgery and surgical oncology department compared to the other departments.

Conclusions: Low compliance was shown with pain assessment in postoperative patients, according to the process indicator pain after surgery in Dutch hospitals. This suggests that the implementation of measuring pain in hospitals is still insufficient.

Volledig artikel in te zien via:
https://www.ncbi.nlm.nih.gov/pubmed/27614250

Part III

Quality of postoperative pain care: outcome

Comparison of epidural or regional analgesia and patient controlled analgesia: a critical analysis of patient data by the acute pain service in a university hospital

4

Clinical Journal of pain 2016, 32(8): 681-688

Rianne L.M. van Boekel
Kris C.P. Vissers
Glenn van de Vossenberg
Mira de Baat-Ananta
Rob van der Sande
Gert Jan Scheffer
Monique A.H. Steegers

Abstract

Objectives: A large number of patients still suffer from pain after surgery. This study investigates if epidural or regional analgesia (CPNB) provide superior pain relief compared to patient controlled analgesia (PCIA) and identifies the incidence of minor and major adverse effects or complications of these techniques.

Methods: Prospectively collected data of postoperative patients from an online data registration system of a special dedicated nurse based acute pain service (APS) were analyzed. The APS consultations were documented from January 2008 to August 2013 in a university hospital in the Netherlands.

Results: An analysis was applied on data of 12,399 consecutive patients. Results showed that patients who received epidural analgesia and CPNB reported lower pain scores than those who received PCIA, after undergoing the same procedures. Additionally, pain scores at rest were significantly lower than movement evoked pain scores, in abdominal surgery. Severe nausea was mostly observed in patients with PCIA and itching was most common in patients with epidural analgesia. Opioid induced respiratory depression was found in five patients with PCIA.

Discussion: Epidural analgesia and CPNB provide better pain relief to patients than PCIA, especially in dynamic pain scores of patients. Evaluating real patient data on every patient visit is important for further improvement of the quality of postoperative pain management. Pain scores may vary widely between patients with similar surgical procedures. Therefore, we recommend that future research focuses on personalized pain measurement and pain management, to improve clinical practice more intensely.

Volledig artikel in te zien via:
https://www.ncbi.nlm.nih.gov/pubmed/26528866

Moving beyond pain scores: multidimensional pain assessment is essential for adequate pain management after surgery

5

Plos One 2017, 12(5): e0177345.

Regina L.M. van Boekel
Kris C.P. Vissers
Rob van der Sande
Ewald Bronkhorst
Jos G.C. Lerou
Monique A.H Steegers

Abstract

Background: Clinical experience teaches us that patients are willing to accept postoperative pain, despite high pain intensity scores. Nevertheless, relationships between pain scores and other methods of pain assessment, e.g. acceptability of pain or its interference with physical functioning, are not fully established. Our aims were to examine these relationships.

Methods: A cross-sectional study was conducted on patients who underwent major surgery between January 2008 and August 2013. Using logistic regression, we quantified the relationships between movement-evoked pain scores on the numerical rating scale (NRS-MEP) and three dichotomous dependent variables: patient's opinion on acceptability of pain (PO: acceptable or unacceptable pain); nurses' observation of patient's performance of necessary activities to expedite recovery (NO: good or bad performance); a compound measure judging the presence of the clinically desirable situation of acceptable pain associated with good patients' performance (PONO: present or not). Using Receiver Operating Characteristics (ROC) analysis, NRS cut-off points were determined such that they best discriminate between patients having one versus the other outcome for PO, NO and PONO.

Results: 15,394 assessments were obtained in 9,082 patients in the first three postoperative days. Nine percent of the patients had unacceptable pain while having an NRS-MEP of 0-4. An estimated 47 % (95 % CI=45 %-49 %) of patients with an NRS-MEP of 7 described their pain as acceptable on day one. Moreover, 33 % (31 %-35 %) performed all required physical activities, and 22 % (21 %-24 %) combined acceptable pain with appropriate movement. NRS cut-off points for PO, NO and PONO were five, four and four, respectively, but had insufficient discriminatory power.

Conclusions: Our results suggest pain management should be guided by the many dimensions of the patient's pain experience, not solely by NRS cut-off points. Future research should evaluate the impact of such multidimensional pain assessment on patients' functional outcome.

Introduction

Many patients experience acute postoperative pain after major as well as minor surgery [1, 2]. Clinical experience teaches us that really adequate treatment of postoperative pain is not easy to achieve. To balance treatment options, treatment starts with assessing the pain. As pain is a complex and subjective experience, also in the postoperative period, various methods exist to evaluate key aspects of acute pain after surgery.

Most of these assessment methods rely on the perception of pain and pain- related phenomena by either the patient or a professional caregiver [3, 4]. Self-assessment of pain by the patient may use a pain intensity scale and yes/no answers to questions such as "Is the pain acceptable?" [5, 6]. Self-reporting values the subjective nature of pain. Evaluation of pain by a professional may include objective assessment of the functional impact of pain. The professional therefore judges if the pain prevents the patient from moving appropriately or from performing the necessary activities to expedite recovery [7]. One clinically important goal could be a level of pain that is not only acceptable for the patient, but also allows the patient to move appropriately as judged by a professional.

The numerical rating scale (NRS), a validated instrument to assess pain intensity by self-reporting, is widely used for assessing pain on a scale from zero (no pain at all) to 10 (worst possible pain). Certain NRS scores have even been used as cut-off points to guide initiation or cessation of treatment in an individual or even as indicator of the quality of pain management in a population [8-10].

Relationships between NRS and other methods of pain assessment, e.g. acceptability of the pain or its interference with physical functioning, are not fully established. In the clinical setting, some patients report a high movement-evoked pain score, yet claim that their pain is acceptable to them [11]. Patients may even refuse to take pain medication when an NRS cut-off point demanding treatment according to a pain protocol is reached or crossed [12]. A further complicating factor is that some patients and pain professionals interpret pain scores differently [3]. As a result of these discrepancies or unclear relationships between different pain assessments, difficulties in treatment decisions may arise.

Our aims therefore were *first*, to quantify relationships between NRS and other methods of pain assessment and *second*, to examine the ability of an NRS cut-off point to predict either patients' willingness to accept pain or functional capacity. Potential benefit of the study is that its results may aid to develop and corroborate clinical guidelines to tailor postoperative pain management in a way that will meet the unique needs of each patient.

Materials and Methods

Approval

The Institutional Review Board of the Radboud university medical center (Nijmegen, The Netherlands) approved the study (2013/428). No informed consent was obtained from the participants because data were anonymized.

Study design and patients

This cross-sectional study was conducted on patients older than 18 years who had been admitted in a large regional academic medical center in the period from 1 January 2008 to 1 August 2013. The study used the prospectively collected pain assessments of postoperative patients who had been treated by the acute pain service (APS).
We quantified the relationships between movement-evoked NRS and acceptability of pain, functional impact of pain, and a measure combining the two. The latter measure serves to judge whether or not a clinically desirable situation occurs where acceptable pain coexists with good physical functioning. A potential influence of gender, age or body mass index (BMI) was investigated.

Data handling

Assessments
The APS nurses use a standardized multidimensional assessment to evaluate postoperative pain. This assessment includes: (1) the NRS for movement-evoked pain (NRS-MEP) [7], (2) the patient's opinion (PO) whether the pain is acceptable because the patient's appreciation of the pain is clinically important for making the patient comfortable [13], and (3) the nurses' observation (NO) on the patient's ability to make appropriate movements. NRS-MEP and NO are important because adequate treatment of pain experienced during pain-provoking maneuvers may reduce complications after surgery [14, 15].
The NRS-MEP is an 11-point numerical rating scale with end points representing the extremes of the pain experience: 0 = "no pain at all" and 10 = "worst possible pain". All nurses and patients received education on how to use the NRS-MEP appropriately [15].
The PO is determined by asking the patient whether the pain is acceptable or not, making it a binary yes-or-no variable [11].
The NO scoring mirrors the Functional Activity Score (FAS) described by Scott and McDonald [16] and adopted by the Australian and New Zealand College of Anaesthetists. The FAS, recommended in several textbooks [17, 18], was recently integrated in the updated Australian and New Zealand guideline on acute pain management [19]. The FAS (designed to be applied at the bedside) is a simple

three-level ranked categorical score to assess whether the patient can undertake appropriate activity at his or her current level of pain control.
The APS nurses rely on an operation-specific protocol offering clearly defined criteria to judge patient's ability to perform physical activities on the first three days after surgery—like coughing, deep breathing, early movement and walking [20]. Some examples of operation-specific protocols are the ability to sit on a chair for thirty minutes on the first morning after a patient has had a laparotomy and the ability to walk to the bathroom for a patient on the first day after a total hip replacement. Patient's performance is qualified as: "good", "moderate" or "bad". A "good" means patient is able to make all appropriate movements and is not hindered by pain. "Bad" means patient is totally unable to make appropriate movements because of the pain. "Moderate" is chosen when observing neither "good" nor "bad". The results for NO are dichotomized into two outcome categories, "good" or "moderate and bad". Accordingly, NO is also a binary yes-or-no variable.
In addition, combining PO and NO yields a third binary yes-or-no variable, i.e. PONO. This variable is not part of the multidimensional assessment at the bedside, but was created for study purposes only. One result for PONO is when "acceptable pain" accompanies "good movements", thus reflecting a clinically desirable situation. The ultimate goal of postoperative pain treatment is that a patient qualifies the pain as acceptable and is able to perform appropriate movements. The other result for PONO is chosen for each of the three remaining combinations of PO and NO.

Database of Acute Pain Service
The nurse-based, anesthesiologist supervised APS is part of the Department of Anesthesiology, Pain and Palliative Medicine. The organization of this type of APS has been described elsewhere [21, 22]. The APS has a team of five dedicated well-trained nurses who strictly use hospital protocols to assess postoperative pain in patients. The APS is available seven days a week and supports the treatment of postoperative pain with specialized or complex pain management techniques. The APS treats patients from the first day after major surgery, but not on the day of surgery. Typical surgical procedures are listed in the supplementary information (see Supplement S1, Table S1 in Supplemental Digital Content S1).
After each visit to a patient, the dedicated nurse enters the obtained data (inter alia values for NRS-MEP, PO and NO) into a new digital record of the APS database. As each visit yields one record in the database, multiple records per patient are possible per day. Data are entered on a mobile handheld computer wirelessly connected with the hospital system for real time registration.
Standard information about postoperative pain and its management is given preoperatively to patients. The information is recorded in a pain protocol. Anesthesiologists give oral information supported by a leaflet during the preoperative consultations. Patients are also invited to watch a movie online. Prior to the actual pain assessment, APS nurses check patient's knowledge and, if necessary, still inform the patient using the appropriate information.

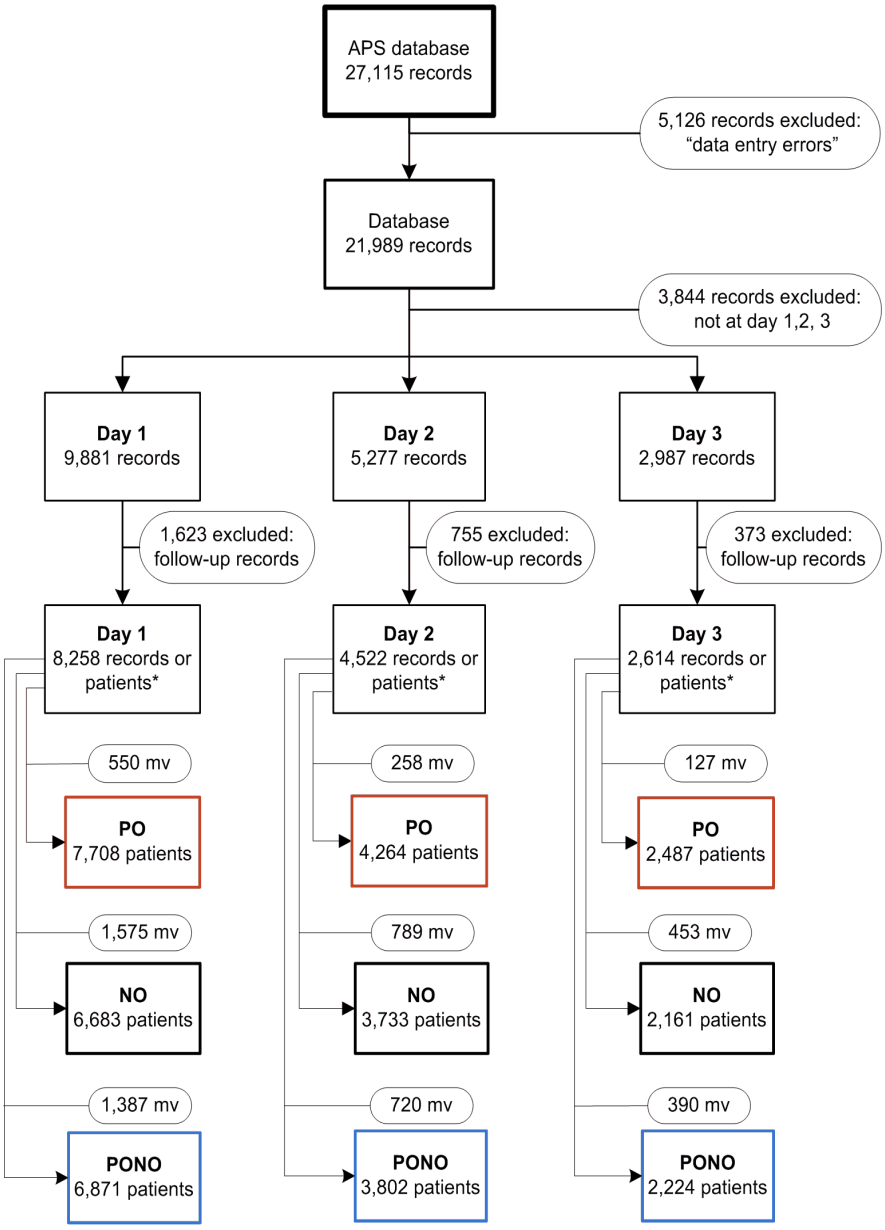

Figure 1 Flow chart: Transforming the database of the Acute Pain Service (APS) into nine data sets

For each of the three postoperative days, three data sets are created: one for patient's opinion (PO), one for nurses' observation (NO) and one for the combined variable (PONO). Results for these nine data sets are shown in Fig 3 and Table 3. *Before this point multiple records are possible per patient but after this point the number of records equals the number of patients. mv=missing values.

Creating data sets

Fig 1 illustrates the various steps to create datasets ready for valid analyses from the APS database. Editing the raw APS database was necessary because of data entry errors. Data entry errors were found in records with pain scores above ten and records where pain scores were not entered or patients were unable to give an NRS score. As multiple records per patient were possible per day for many days in a row, we made a selection first, by taking the records of the visits of the first three days after surgery and second, by selecting the record of the first visit to a patient per day to stay in the database. As a result, the number of records equaled the number of patients on day 1, day 2, and day 3 after surgery.

As the APS database consists of the real time online registration during the work of the APS nursing staff, some missing values were also inevitable. These missing values were counted per day for the PO-, NO- and PONO-variables (Fig 1). To avoid the bias that would be induced by restricting the analyses to patients without missing observations, we did not exclude patients because of incompleteness of the pain assessments.

Statistical analysis

To explore the relationships between PO, NO, PONO and NRS-MEP, the relative frequencies of the two possible outcomes for PO, NO, and PONO during the first three postoperative days were pooled and were plotted against the NRS for MEP. To quantify these relationships, a logistic regression model was estimated using the 11-point NRS for MEP as primary independent explanatory variable for each of the three dependent variables PO, NO, and PONO. Thus PO, NO, and PONO

Table 1 Name, abbreviation, values and coding of variables used in the logistic regression models to estimate the relationships between four explanatory variables and each of three response variables

	Variable name	Abbreviation	Values	Coding
Explanatory variables	Numerical Rating Scale	NRS	0–10	0 = no pain 10 = worst pain imaginable
	Age	A	0 or 1	0 = younger than 65 years 1 = 65 years or older
	Gender	G	0 or 1	0 = female 1 = male
	Body mass index	BMI	0 or 1	0 = BMI < 30 kg m-2 1 = BMI ≥ 30 kg m-2
Response variables (One per model)	Patient's opinion	PO	0 or 1	0 = pain is not acceptable 1 = pain is acceptable
	Nurses' observation	NO	0 or 1	0 = no appropriate movement 1 = appropriate movement
	Combined PO+NO	PONO	0 or 1	1 = PO=1 and NO=1 0 = otherwise

served as gold standards. As gender, age and BMI may influence the results, these patient characteristics were introduced as extra dichotomous explanatory variables (covariates) into the logistic model [9, 23-25]. Details on the model variables are given in Table 1. A model was calculated for each of the three postoperative days.

Receiver Operating Characteristics (ROC) curves were made to estimate the ability of the computed models to correctly discriminate between those who found their pain acceptable or not, made appropriate movements or not, and those who combined acceptable pain with appropriate movements or not. First the sensitivity and specificity of NRS-MEP were calculated for each of the 11 points of the NRS-MEP score. Then the sensitivities (true positive fractions of subjects) were plotted versus 1-specificities (false positive fractions of subjects) to obtain the ROC curves. The area under the curve (AUC) quantifies how well the NRS-MEP predicts PO, NO or PONO: the larger the area, the better. If AUC=1.0, sensitivity and specificity equal both 100 %. If AUC=0.5, use of NRS-MEP is no better than flipping a coin.
The statistically optimal cut-off point was determined where the sum of the sensitivity and the specificity minus one (Youden's J-statistic) was maximal. Thus sensitivity and specificity were regarded as being equally important. This is the best cut-off point for the prediction of a positive response under the condition of equal "costs" of misclassifications.
The Statistical Package for the Social Sciences (IBM SPSS version 22.0; IBM Corporation, New York, NY, USA), Statistical Analysis System (SAS version 9.2; SAS Institute Inc., Cary, NC, USA), and R (R version 3.1.2 (2014-10-31); The R Foundation for Statistical Computing, Vienna, Austria) were used. Threshold of statistical significance was 0.05.

Results

Patient characteristics

15,394 assessments were obtained in 9,082 unique individual patients. For each of these patients data were obtained on: one of the three postoperative days, or any combination of two days, or all three days. Consequently, we had data from these 9,082 individual patients for 8,258, 4,522 and 2,614 of them on day 1, day 2 or

Table 2 Numbers and characteristics of patients

Day after surgery	N	Male (%)	Age (years) (mean (SD))	BMI (kg m-2) (mean (SD))*
1	8,258	44.0	53.5 (16.3)	26.2 (4.9)
2	4,522	51.5	56.5 (15.4)	25.8 (4.7)
3	2,614	55.5	56.8 (15.3)	25.7 (4.6)

* Because of missing values for length and/or weight the means (SD) for BMI are based on 8,042, 4,406, and 2,546 patients for day 1, day 2 and day 3, respectively.

day 3, respectively (Fig 1). The number of patients diminished across the three days as a part of the patients left the hospital after one or two days. A detailed account of the numbers of patients and assessments is given in Supplement S2 (see Table S2 in Supplemental Digital Content S2, which is a comprehensive table listing the number of patients, the number of unique, individual patients and the number of assessments of patients categorized per day or per combination of days).
Table 2 shows patients' characteristics categorized per day. They were similar when further categorized per data set.

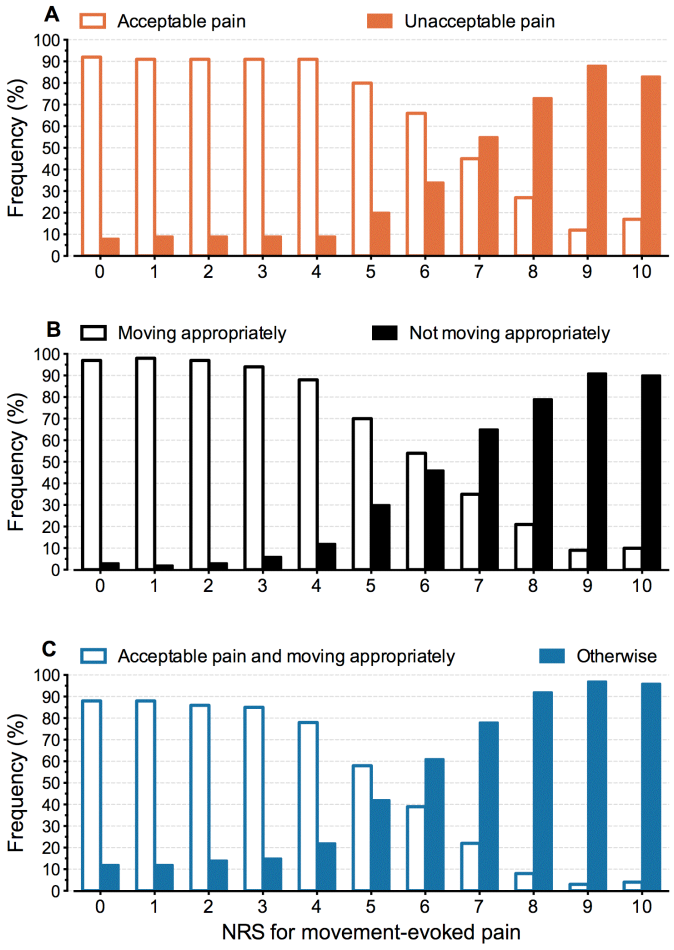

Figure 2 Relative frequencies for observations of patients' opinion (A), nurses' observation (B), and the measure combining patient's opinion and nurses' observation (C) against NRS-MEP scores
The observations in all patients gathered during the first three postoperative days were pooled.

Relationships between components of pain assessment

Observations

Fig 2 depicts the nature of the relationships between components of pain assessment. Pooled observed relative frequencies for PO, NO and PONO are plotted against NRS-MEP scores. The sigmoid shape of the relationships suggests using a logistic model for further analysis.

Fig 2A shows the observed relationship between the NRS-MEP scores and the acceptability of the pain. Patients associated low NRS-MEP scores 0-4 with unacceptable pain in approximately 9 % of the observations. On average, in 23 % of the observations patients with an NRS-MEP of 8-10 considered their pain acceptable.
Fig 2B shows that, on average, in 17 % of the observations patients with an NRS-MEP of 8-10 showed appropriate movements.
Fig 2C shows the observed relationship between the NRS-MEP scores and the presence of a clinically desirable situation where acceptable pain coexists with pain-free physical functioning. This situation is present in 22 % of the observations with an NRS-MEP=7, and, on average, in 7 % of the observations with an NRS-MEP of 8-10.

Model-based relationships

Binary logistic regression analysis revealed strong mathematical relationships between components of pain assessments, but age, gender and BMI were of no influence. All fitted models were adequate (likelihood ratio statistic: all P- values < 0.001).
NRS-MEP was related to PO, NO or PONO on each of the three postoperative days (all P-values < 0.001). The procedure to assess the influence of age, gender and BMI on the prediction models yielded 27 P-values (three days times three covariates times three response variables). Of these 27 P-values, only one was below the threshold of statistical significance (P=0.0423 for gender on the prediction of NO on day 1). As even in the absence of any relation between these covariates and the three outcomes, by pure chance one out of 20 P-values can be expected to be <0.05, these P-values were interpreted as indication that extension of the models with these covariates was not indicated. Therefore, we only present analyses using NRS-MEP as sole covariate. Details on the estimated models, including estimated regression coefficients, odds ratios and ROC curves, are given in Supplement S3 (see Table S3).
Fig 3 shows the estimated logistic curves with their 95 % confidence bands for the nine data sets created as shown in Fig 1. Wider 95 % confidence bands reflect smaller numbers of patients. Each of the curves shows the estimated proportion of patients that possess the outcome measure of interest as a function of NRS-MEP

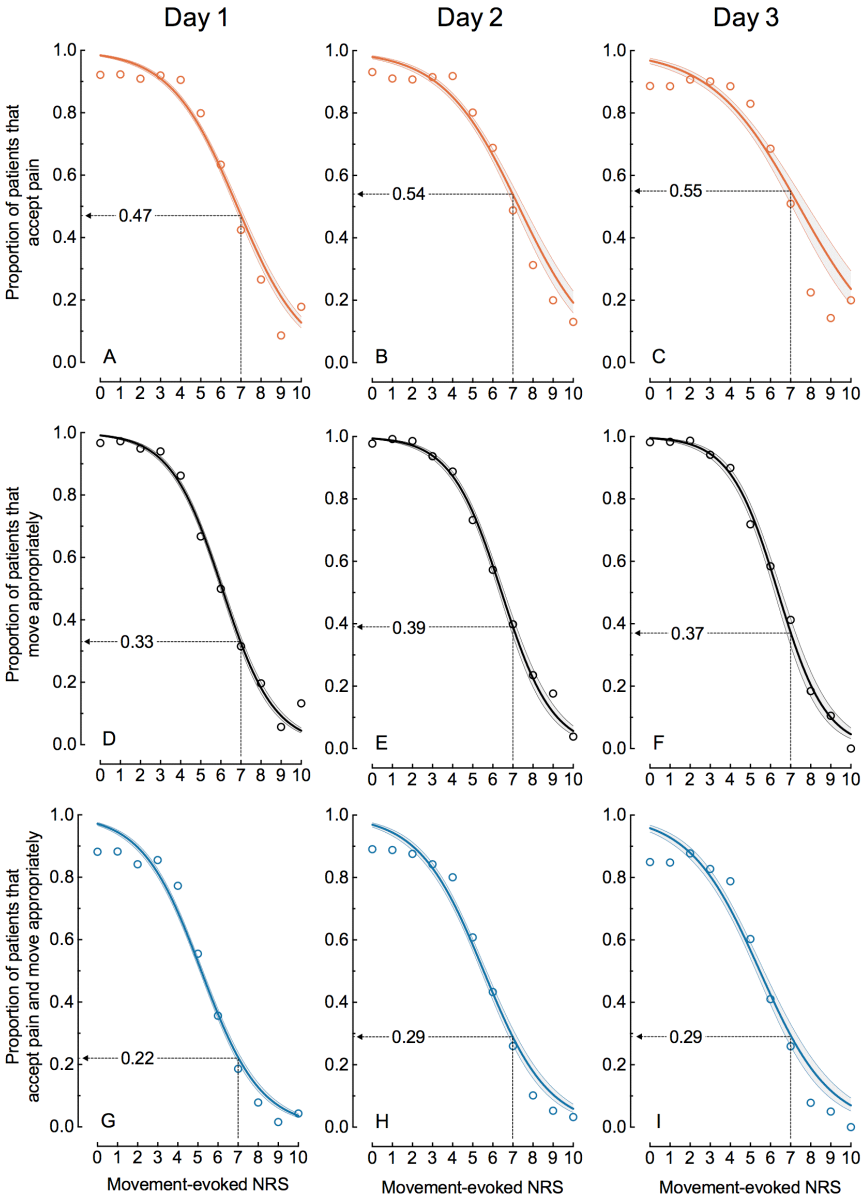

Figure 3 Estimated proportion (solid curve with its 95 % confidence band) of patients that accept the pain (A-C), move appropriately (D-F) or accept the pain and move appropriately (G-I) as a function of NRS-MEP for day 1, 2 and 3 after surgery

The open circles represent the observed proportions of patients at each of the eleven points of the NRS. For each of the nine data sets, one estimated proportion is computed and shown at NRS-MEP = 7.

Table 3 Cut-off points obtained from the logistic regression model using the 11-point Numerical Rating Scale for movement-evoked pain as explanatory variable for each of the three dependent variables PO, NO, and PONO. Shown are the statistically optimal cut-off points with their associated sensitivities and specificities, as well as the areas under the ROC curves (AUC)

Day after surgery	Dependent variable	N	Cut-off point	Sensitivity (%)	Specificity (%)	AUC	(95 % CI)
1	PO	7,708	5	83	68	0.81	(0.79-0.82)
	NO	6,683	4	71	87	0.86	(0.85-0.87)
	PONO	6,871	4	75	80	0.84	(0.83-0.84)
2	PO	4,264	5	83	61	0.77	(0.75-0.79)
	NO	3,733	4	69	87	0.86	(0.84-0.87)
	PONO	3,802	4	73	77	0.81	(0.79-0.82)
3	PO	2,487	5	87	53	0.73	(0.71-0.76)
	NO	2,161	4	76	85	0.87	(0.85-0.89)
	PONO	2,224	4	79	69	0.79	(0.76-0.81)

PO, patient's opinion on whether the pain is acceptable; NO, nurses' observation on the patient's ability to make appropriate movements; PONO, combined measure of PO and NO: is "acceptable pain" associated with "good appropriate movements" or not. Details on PO, NO, and PONO are given in Table 1.

[26]. The estimated curves for NO strongly match the data for nurses' observations indicated by open circles. For PO and PONO the curves closely follow observed proportions for 3≤NRS≤8 but mostly overpredict the observations for NRS≤2 and NRS≥9.

Fig 3 shows that, despite an NRS-MEP = 7, roughly half of the patients accept the pain (Fig 3A-C) and at least one third of the patients move appropriately (Fig 3D-F). Fig 3 suggests that these proportions increase with time. In spite of an NRS-MEP=7, at least one patient in five finds the pain acceptable and moves appropriately (Fig 3G-I): estimated proportions are 0.22 (95 % CI=0.21-0.24), 0.29 (95 % CI=0.26-0.31) and 0.29 (95 % CI=0.26-0.33) for day 1, 2 and 3, respectively.
Table 3 presents the statistically optimal cut-off points with their associated sensitivities and specificities. The number of patients decreases across the days. The cut-off points, however, remain stable: five, four, and four for PO, NO and PONO, respectively. Fig 4 shows graphs of the ROC curves. The closer a ROC curve is to the upper left corner, the better NRS-MEP discriminates between those patients who experience the outcome of interest, e.g. the pain is acceptable, versus those who do not.
The AUC for PO decreases across the days from 0.81 to 0.73. The latter figures indicate that NRS-MEP is not a perfect predictor for patients' willingness to accept their pain. The areas under the curve for NO are larger than those for PO and PONO on each of the three days. The AUC for NO implies that the NRS-MEP is fairly accurate in predicting the NO for all three days [27].
Four is the statistically optimal cut-off point for NRS-MEP based on the combination of patients' opinion and the nurses' observation. Nevertheless, 17 %, 15 % and 17

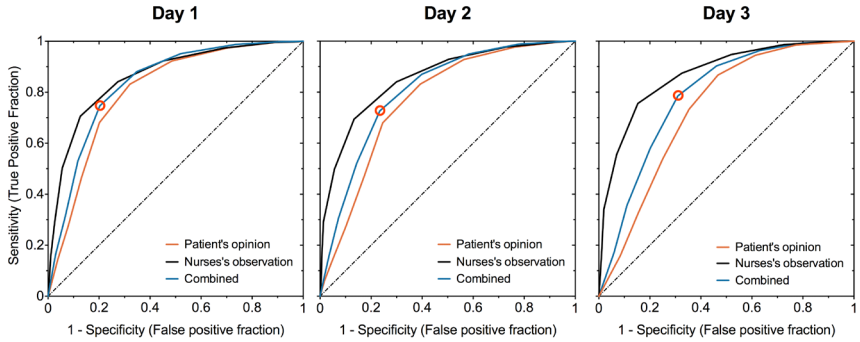

Figure 4 ROC curves for the dependent variables PO, NO and PONO for the three first postoperative days

The dashed line is the line of identity where the AUC = 0.5. Open circles are the points where Youden's J-statistic is maximal for PONO. These points are, by definition, the 'optimal' cut-off points.

% of those patients, who scored an NRS-MEP≤4, found their pain unacceptable or did not show good physical functioning or both, on day 1, 2, and 3, respectively. Fig 3G shows that the steepest part of the sigmoid curve starts at the cut-off point (odds ratio=0.51 with its 95 % CI=0.49-0.52 for day 1; other odds ratios are given in Supplement S3 (see Supplemental Digital Content S3)).

Discussion

To our knowledge, this is the first study in a broad surgical population to quantify the relationships between movement-evoked NRS and acceptability of pain, functional impact of pain, and a measure combining the two as a clinically desirable situation. Since the outcome of pain assessments has clinical consequences for all surgical patients, we consider our findings important to all health professionals involved in peri-operative care.

This study shows that the unidimensional NRS does not entirely reflect the multidimensional aspects of postoperative pain. Low pain scores do not guarantee that patients find their pain acceptable. Nor do high pain scores invariably mean that patients are not satisfied by their pain levels. Approximately one out of ten patients had unacceptable pain but reported a low NRS-MEP of 0-4. Despite a high pain score of NRS-MEP=7, at least one in five patients were willing to accept their pain and, at the same time, performed the required physical activities (Fig 3G-I).

According to the Youden's index, we found an 'optimal' NRS cut-off point for PONO of four. However, this threshold value is a rather poor predictor at the patient's level. Approximately 16 % of those patients who score an NRS-MEP equal to or lower than four, found their pain unacceptable or did not show good physical functioning or both. Taken together, the body of our findings points out that caregivers should prefer multidimensional assessment of pain, moving beyond the sole use of cut-off

points on the NRS to make clinical decisions.
Generally, low pain scores will not encourage health professionals to adjust pain treatment [28]. When health professionals do not ask patients whether pain is acceptable to them, pain may be undertreated. On the other hand, our study confirms the willingness of many patients to accept high-intensity pain. Maroney and co-workers observed that 31 percent of 1,249 patients, who reported severe pain on a four-item scale, found their pain acceptable [11]. In our larger study 23 % of patients, on average, proved to tolerate their pain despite an NRS-MEP of 8-10 (Fig 2A). At NRS-MEP=7, the estimated proportion of patients tolerating their pain was even 55 % (95 % CI=51 %-59 %) on the third postoperative day (Fig 3C). These discrepancies may be explained by patients' satisfaction with postoperative pain treatment, which may be more associated with impressions of improvement and appropriateness of care than with the actual pain experience [29, 30]. Additionally, patients and caregivers interpret pain intensity scores differently [3]. A recent study showed that some patients are not able to use the NRS reliably [31]. Patients may choose not to take more analgesics because they interpret their pain as "bearable" [12, 32]. Professionals need to be aware of this complex array of factors determining patients' experience of the pain. Therefore, the patient perspective should be assessed and valued in the care process [29].
To fully estimate patients' experience of pain an NRS score is not sufficient and other dimensions of pain should be assessed to balance treatment options [33, 34]. The internationally recognized definition by the International Association for the Study of Pain is: "Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" [35]. McCaffrey and Beebe offer another definition:"Pain is whatever the experiencing person says it is, existing whenever the experiencing person says it does" [36]. Both of these definitions highlight that a painful experience is more than just tissue damage triggering a response from the nervous system. The management of pain thus involves more than simply treating the tissue injury [37-39]. NRS-scores should be interpreted individually, after communicating with patients about their pain and observing them [12]. Observing the capacity to mobilize, breathe deeply or cough may inform the professional on the functional capacity of the patient in relation with the pain score [7]. Restrictions of these activities may be a consequence of inadequate analgesia, which may not be discovered solely with patient-reported outcomes [4].
As nurses have more patient contacts than other health professionals, regular pain assessment and reassessments usually fall to the nursing domain [40]. Pain assessment is a complex communication process between the patient and health professional with diverse interpersonal and intrapersonal dimensions interacting and affecting each other [13, 41]. In this way a balanced decision on pain treatment can be described as the result of a social transaction between the patient and the health professional [13, 42]. The combination of the patients' opinion and the nurses' observation, as the balancing variable, may therefore be a first step in the direction of the future.

A specified value on the NRS has been frequently used as a single 'cut-off point' to divide patients into two categories: those who are in need of pain treatment and those who are not [8]. However, cut-off points are far from perfect discriminators between the two categories (Table 3). Also, there is no convincing evidence for the choice of a certain cut-off point, and consequently no consensus [8, 12, 15]. Threshold values of six [9], seven [15], or eight have been used to define the lower limit for severe pain. The Dutch Health Care Inspectorate classifies NRS ≥ 8 as severe pain and considers the percentage of patients with an NRS 8-10 to be a quality indicator of postoperative pain management [10]. Furthermore, there is no evidence that the use of cut-off points improves pain control [13].

The "optimal" cut-off point for NRS-MEP we defined here holds under the condition that costs of misclassifications are equal, thus weighing under- and over-treatment equally. However, our choice for this equality cannot be corroborated because it is unknown what is more harmful. In this study no outcome data were included and therefore we cannot discuss our results from this perspective. Nevertheless, we may point out two directions for future research. On one hand, questions should be answered whether treating unacceptable pain and better education of patients and professionals may prevent pain-related complications [14]. On the other hand, a hypothesis to be tested is: "Treating pain during routine hospital ward care, only because a pain score is higher than a predefined cut-off value, is potentially hazardous".

In our study, we did not exclude patients because of incompleteness of the pain assessments. By doing so, we avoid the bias that would be induced by restricting the analyses to only patients without missing observations, the so-called complete case analysis. A complete case analysis is unbiased if data are missing completely randomly, meaning that the chance of data being missing is unrelated to any of the variables involved in the analysis. If data are not missing completely randomly, analyzing only the complete cases will probably lead to biased estimates [43]. Even when complete case analysis would be unbiased, discarding all the information from the incomplete cases is inefficient.

This study has limitations. First, there are no "gold standard" objective measures of the pain-related functional capacity in postsurgical patients [44]. Nevertheless, various measures have been developed to quantify treatment related changes in the physical abilities of individuals with acute pain [4, 16]. The FAS is such a nonvalidated —because of lacking standards— measure. Not only has the FAS been adopted by the Australian and New Zealand College of Anaesthetists and Faculty of Pain Medicine [19], but also it has been advocated for clinical use [16-18]. The FAS proved to be very useful and generally applicable in daily practice. Second, we could not include all confounding factors. Gender, age and BMI were introduced as covariates in the logistic model because they are risk factors for the development of acute postoperative pain [9, 23-25]. Gender, age and BMI showed no influence, but we do not know if other factors might. Other factors may be: type of operation, anxiety or catastrophizing [9, 45], preoperative information, expectations about pain levels, psychological profile and motivation. The impact of these factors with the

relationships between NRS-MEP, PO, NO and PONO could be a topic of future prospective studies. For example, pain anticipation can be assessed by asking the patient preoperatively to mark a point on the NRS that describes the anticipated pain after surgery [46]. Third, our findings do not apply to all hospitalized patients because we only studied patients after major surgery. One next step is to validate our results for other patient categories, such as patients after minor surgery and patients with cancer pain.

Conclusions

The nature and strength of the relationships we found lead to clinically important findings and implications. Almost one in ten patients has unacceptable pain even if they report a low pain score. One in five patients with a high pain score accepts the postoperative pain and still moves appropriately. We encourage health professionals to use a multi-source pain evaluation by assessing NRS, the acceptability of the pain and physical functioning in order to balance pain treatment options and possible complications. The sole use of NRS cut-off points is not adequate. Adequate pain assessment appears to become a form of social transaction between patient and caregiver. Future research should focus on the improvement in pain-related outcomes in relation to multidimensional pain assessment and treatment decisions.

Acknowledgements

We would like to thank Jan C.M. Hendriks, MSc, PhD (retired), Department of Medical Statistics, Radboud University Medical Center, Nijmegen, The Netherlands, for the initial statistical analyses. We are also very grateful to Prof. dr. Narinder Rawal, who reviewed an early version of the manuscript. His feedback helped us to compose the final manuscript.

References

1. Sommer, M., et al., The prevalence of postoperative pain in a sample of 1490 surgical inpatients. Eur J Anaesthesiol, 2008. 25(4): p. 267-74.
2. Gerbershagen, H.J., et al., Pain intensity on the first day after surgery: a prospective cohort study comparing 179 surgical procedures. Anesthesiology, 2013. 118(4): p. 934-44.
3. van Dijk, J.F., et al., Postoperative pain assessment based on numeric ratings is not the same for patients and professionals: a cross-sectional study. Int J Nurs Stud, 2012. 49(1): p. 65-71.
4. Rothaug, J., et al., Patients' perception of postoperative pain management: validation of the International Pain Outcomes (IPO) questionnaire. J Pain, 2013. 14(11): p. 1361-70.
5. Williamson, A. and B. Hoggart, Pain: a review of three commonly used pain rating scales. J Clin Nurs, 2005. 14(7): p. 798-804.
6. Rothaug, J., T. Weiss, and W. Meissner, How simple can it get? Measuring pain with NRS items or binary items. Clin J Pain, 2013. 29(3): p. 224-32.
7. Srikandarajah, S. and I. Gilron, Systematic review of movement-evoked pain versus pain at rest in postsurgical clinical trials and meta-analyses: a fundamental distinction requiring standardized measurement. Pain, 2011. 152(8): p. 1734-9.
8. Gerbershagen, H.J., et al., Determination of moderate-to-severe postoperative pain on the numeric rating scale: a cut-off point analysis applying four different methods. Br J Anaesth, 2011. 107(4): p. 619-26.
9. Janssen, K.J., et al., The risk of severe postoperative pain: modification and validation of a clinical prediction rule. Anesth Analg, 2008. 107(4): p. 1330-9.
10. Dutch Health Care Inspectorate. Basic set for quality indicators for hospitals. 2014 [cited 2015 18 May]; Available from: www.ziekenhuizentransparant.nl.
11. Maroney, C.L., et al., Acceptability of severe pain among hospitalized adults. J Palliat Med, 2004. 7(3): p. 443-50.
12. van Dijk, J.F., et al., The Relation Between Patients' NRS Pain Scores and Their Desire for Additional Opioids after Surgery. Pain Pract, 2015. 15(7): p. 604-9.
13. Gordon, D.B., Acute pain assessment tools: let us move beyond simple pain ratings. Curr Opin Anaesthesiol, 2015. 28(5): p. 565-9.
14. Wu, C.L. and S.N. Raja, Treatment of acute postoperative pain. Lancet, 2011. 377(9784): p. 2215-25.
15. Breivik, H., et al., Assessment of pain. Br J Anaesth, 2008. 101(1): p. 17-24.
16. Scott, D.A., W. McDonald, Acute pain management performance measurement toolkit. 2005, Melbourne: Victorian Quality Council, Department of Human Services.
17. Macintyre, P., D. Rowbotham, and S. Walker, Clinical Pain Management Second Edition: Acute Pain, Volume 1. 2008; 148: Taylor & Francis.
18. MacIntyre PE, S.D., Acute Pain Management and Acute Pain Services, in Cousins and Bridenbaugh's Neural Blockade in Clinical Anesthesia and Pain Medicine, M.J. Cousins, et al., Editors. 2009; 1043, Lippincott Williams & Wilkins.
19. Schug, S.A., et al., Acute pain management: scientific evidence, fourth edition, 2015. Med J Aust, 2016. 204(8): p. 315-7.
20. Helfand, M. and M. Freeman, Assessment and Management of Acute Pain in Adult Medical Inpatients: A Systematic Review. Pain Medicine, 2009. 10(7): p. 1183-1199.
21. Rawal, N. and L. Berggren, Organization of acute pain services: a low-cost model. Pain, 1994. 57(1): p. 117-23.
22. van Boekel, R.L., et al., Comparison of Epidural or Regional Analgesia and Patient-controlled Analgesia: A Critical Analysis of Patient Data by the Acute Pain Service in a University Hospital. Clin J Pain, 2016. 32(8): p. 681-8.
23. Gerbershagen, H.J., et al., Procedure-specific risk factor analysis for the development of severe postoperative pain. Anesthesiology, 2014. 120(5): p. 1237-45.
24. Massaron, S., et al., Analysis of post-surgical pain after inguinal hernia repair: a prospective study of 1,440 operations. Hernia, 2007. 11(6): p. 517-25.
25. Liu, S.S., et al., Predictors for moderate to

severe acute postoperative pain after total hip and knee replacement. Int Orthop, 2012. 36(11): p. 2261-7.
26. Hosmer DW, Lemeshow S. Introduction to the Logistic Regression Model. In: Applied Logistic Regression: John Wiley & Sons, Inc., 2005; 1-30
27. Galley, H.F., Editorial II: Solid as a ROC. Br J Anaesth, 2004. 93(5): p. 623-6.
28. Aubrun, F., et al., Relationships between measurement of pain using visual analog score and morphine requirements during postoperative intravenous morphine titration. Anesthesiology, 2003. 98(6): p. 1415-21.
29. Schwenkglenks, M., et al., Correlates of satisfaction with pain treatment in the acute postoperative period: results from the international PAIN OUT registry. Pain, 2014. 155(7): p. 1401-11.
30. Gan, T.J., et al., Incidence, patient satisfaction, and perceptions of post-surgical pain: results from a US national survey. Curr Med Res Opin, 2014. 30(1): p. 149-60.
31. Oudejans, L., et al., Translation of random painful stimuli into numerical responses in fibromyalgia and perioperative patients. Pain, 2016. 157(1): p. 128-36.
32. Harting, B., et al., An exploratory analysis of the correlation of pain scores, patient satisfaction with relief from pain, and a new measure of pain control on the total dose of opioids in pain care. Qual Manag Health Care, 2013. 22(4): p. 322-6.
33. Sloman, R., et al., Determination of clinically meaningful levels of pain reduction in patients experiencing acute postoperative pain. Pain Manag Nurs, 2006. 7(4): p. 153-8.
34. Clark, W.C., et al., Unidimensional pain rating scales: a multidimensional affect and pain survey (MAPS) analysis of what they really measure. Pain, 2002. 98(3): p. 241-7.
35. Merskey, H., Logic, truth and language in concepts of pain. Qual Life Res, 1994. 3 Suppl 1: p. S69-76.
36. McCaffery, M., Nursing practice theories related to cognition, bodily pain and man-environmental interactions, Los Angeles, CA: 1968. UCLA Students Store.
37. Merskey, H., The definition of pain. European Psychiatry, 1991. 6(4): p. 153-159.
38. Anand, K.J. and K.D. Craig, New perspectives on the definition of pain. Pain, 1996. 67(1): p. 3-6; discussion 209-11.
39. Wikstrom, L., et al., Healthcare professionals' perceptions of the use of pain scales in postoperative pain assessments. Appl Nurs Res, 2014. 27(1): p. 53-8.
40. Ista, E., M. van Dijk, and T. van Achterberg, Do implementation strategies increase adherence to pain assessment in hospitals? A systematic review. Int J Nurs Stud, 2013. 50(4): p. 552-68.
41. van Dijk, J.F., et al., Postoperative patients' perspectives on rating pain: A qualitative study. Int J Nurs Stud, 2016. 53: p. 260-9.
42. Schiavenato, M. and K.D. Craig, Pain assessment as a social transaction: beyond the "gold standard". Clin J Pain, 2010. 26(8): p. 667-76.
43. Bartlett, J.W., O. Harel, and J.R. Carpenter, Asymptotically Unbiased Estimation of Exposure Odds Ratios in Complete Records Logistic Regression. Am J Epidemiol, 2015. 182(8): p. 730-6.
44. White, P.F. and H. Kehlet, Improving postoperative pain management: what are the unresolved issues? Anesthesiology, 2010. 112(1): p. 220-5.
45. Goesling, J., et al., Trends and predictors of opioid use after total knee and total hip arthroplasty. Pain, 2016. 157(6): p. 1259-65.
46. Carr, E.C. and V.J. Thomas, Anticipating and experiencing post-operative pain: the patients' perspective. J Clin Nurs, 1997. 6(3): p. 191-201.

Table S1 Surgical procedures, categorized in ten groups

Group	N	Procedure
Laparotomy	3,610	Hyperthermic Intraperitoneal Chemotherapy (HIPEC), colectomy, hepatectomy, Whipple procedure (pancreaticoduodenectomy), pelvic or retroperitoneal lymph node dissection, Oscar Ramirez procedure (abdominoplasty), adhesiolysis.
Upper laparotomy	1,857	Gastrectomy, pancreatectomy, splenectomy, esophageal resection, cholecystectomy.
Lower laparotomy	2,792	Abdominal hysterectomy, appendectomy, cystectomy, prostatectomy, sectio caesarea, debulking, rectum or sigmoid resection.
Laparoscopy	581	Laparoscopic cholecystectomy, nephrectomy, colectomy, adrenalectomy, prostatectomy, hysterectomy.
Sternotomy	62	Coronary bypass, thymectomy, metastasectomy, pericard resection.
Thoracotomy	943	Lobectomy, pneumectomy, tracheal resection.
Thoracoscopy	402	Video assisted surgery or thorascopic surgery, such as pleurectomy, bullectomy, Nussbar surgery, video-assisted thorascopic surgery.
Flank	311	Nephrectomy, adrenalectomy.
Orthopaedic surgery	2,966	Total knee arthroplasty, total hip arthroplasty, acetabulum arthroplasty, arthrodesis of limbs, arthrotomy, osteotomy, amputation of limbs, pelvectomy, total shoulder arthroplasty, hand surgery, foot surgery.
Remainder of procedures	1,870	Hernia inguinalis, mastectomy, lumpectomy, laminectomy, spondylodesis, head or face surgery.

Table S2 Number of patients, number of unique, individual patients and the number of assessments of patients categorized per day or per combination of days

Pain assessment on	Day 1	Day 2	Day 3	Unique patients	Assessments
Only day 1	4,327	0	0	4,327	4,327
Only day 2	0	393	0	393	393
Only day 3	0	0	88	88	88
Day 1 & 2	1,748	1,748	0	1,748	3,496
Day 1 & 3	145	0	145	145	290
Day 2 & 3	0	343	343	343	686
Day 1 & 2 & 3	2,038	2,038	2,038	2,038	6,114
Total	**8,258**	**4,522**	**2,614**	**9,082**	**15,394**

Supplement S3 Results from logistic regression

Using the sample data, an iterative process (maximum likelihood) produces an estimated logistic regression equation of the form

$$logit(p) = log_e \frac{p}{1-p} = a + b_1 NRS + b_2 A + b_3 G + b_4 BMI \quad (1)$$

where:

- NRS, A, G and BMI are the explanatory variables (Table 1 in the Methods section);
- *p* is the estimated value of the true probability that a patient with a particular set of values for the explanatory variables has the outcome of interest, for example the patient moves appropriately;
- a is the estimated constant term;
- b_1, b_2, b_3, and b_4 are the estimated logistic regression coefficients.

We can manipulate equation (1) to estimate the probability that a patient has the outcome of interest. After simplifying (as A, G and BMI proved to be of no influence), we first calculate for a patient with a particular NRS,

$$S = a + b_1 NRS \quad (2)$$

Then, the probability that a patient has the outcome of interest is estimated as

$$p = \frac{e^S}{1+e^S} \quad (3)$$

and the probability that a patient does not have the outcome of interest as

$$1 - p = \frac{1}{1+e^S} \quad (4)$$

The probability p decreases from one to zero, for S decreasing from plus to minus infinity. Noticeably, equation (3) shows that the probability p=0.5 for S=0 or $NRS = -a/b_1$. Table S3.1 lists the estimated constant terms and logistic regression coefficients.

Table S3 Results from the logistic regression model using the 11--points Numerical Rating Scale for movement--evoked pain as explanatory variable for each of the three dependent variables PO, NO, and PONO. Listed are constant term α and logistic regression coefficient b_1 from equation (2), as well as the odds ratio (OR) with its 95 % Wald confidence interval

Day after surgery	Dependent variable	α (SE)	b_1 (SE)	OR (95 % CI)
1	PO	4.1156 (0.0943)	-0.6039 (0.0166)	0.547 (0.529-0.565)
	NO	4.7171 (0.1120)	-0.7773 (0.0197)	0.460 (0.442-0.478)
	PONO	3.5161 (0.0871)	-0.6805 (0.0169)	0.506 (0.490-0.523)
2	PO	3.8677 (0.1243)	-0.5303 (0.0224)	0.588 (0.563-0.615)
	NO	5.0953 (0.1651)	-0.7912 (0.0288)	0.453 (0.428-0.480)
	PONO	3.4504 (0.1156)	-0.6220 (0.0224)	0.537 (0.514-0.561)
3	PO	3.4035 (0.1430)	-0.4578 (0.0275)	0.633 (0.600-0.668)
	NO	5.3441 (0.2248)	-0.8378 (0.0402)	0.433 (0.400-0.468)
	PONO	3.1292 (0.1364)	-0.5719 (0.0280)	0.564 (0.534-0.596)

PO, patient's opinion on whether the pain is acceptable; NO, nurses' observation on the patient's ability to make appropriate movements; PONO, combined measure of PO and NO: is "acceptable pain" associated with "good appropriate movements" or not.

The values in Table S3 can be used to calculate S (eq. 2) and the probabilities given in equations (3) and (4). For example, a patient has NRS=4 on day 1. The probability that this patient moves appropriately is 0.833, whereas the probability of not moving appropriately is 0.167. The odds of moving appropriately is *p/(1-p)* = 0.833/0.167 = 4.99. Alternatively, combining equations (3) and (4) yields *p/(1-p)* = e^{S} = $e^{4.7171-0.7773x4}$ = 4.99.

Although mathematically correct, we should not apply estimates on the probability scale to individual subjects like we did in the example. Each individual subject reporting NRS=4 either does or does not move appropriately. The estimated probabilities from a logistic regression model are best viewed as estimates of proportions in the underlying population. As a result, we better express the result for the example as: the estimated proportion of patients that move appropriately at NRS=4 is 0.833. A confidence interval for an estimated proportion can be calculated. We therefore refer to Hosmer and Lemeshow.[†]

The odds ratio (OR) in the example is calculated as follows. For an *NRS*=4, it is the estimated odds of moving appropriately for *NRS*=5 relative to the estimated odds of moving appropriately for *NRS*=4. As the odds with *NRS*=5 is $e^{4.7171-0.7773x5}$ = 2.30, the OR = 2.30/4.99 = 0.46. Alternatively, it can be shown that the OR = e^{b1} = $e^{-0.7773}$ = 0.46, as NRS increases by one unit. If the OR is equal to one, then the two odds are the same. An OR > 1 indicates an increased odds of moving appropriately, and an OR < 1 indicates a decreased odds of moving appropriately, as *NRS* increases by one unit.

A measure of the model's ability to discriminate between those subjects who experience the outcome of interest versus those who do not is provided by the area under the Receiver Operating Characteristic (ROC) curve (Figure S1).[††] It plots sensitivity (true positive fraction of subjects) *versus* 1-specificity (false positive fraction of subjects) at all possible cutoff points on the NRS.[§] The 'optimal' cutoff point is found where the vertical distance between the curve and the line of identity is maximal (Youden's J--statistic).

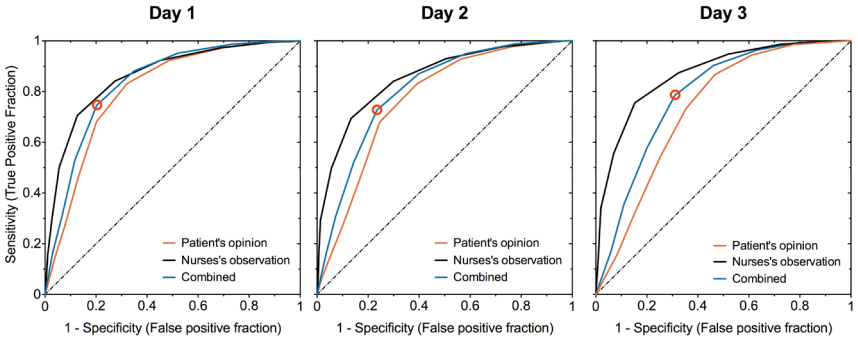

Figure S1

ROC curves for the dependent variables PO, NO and PONO for the three first postoperative days. The dashed line is the line of identity where the AUC = 0.5. The closer the ROC curve is to the upper left corner, the better NRS discriminates. Open circles are the points where Youden's J--statistic is maximal for PONO.

[†] Hosmer DW and Lemeshow S. In: Applied Logistic Regression, 2nd Ed, Chapter 1, p.17--21. ISBN 0--471--35632--8.

[††] Hosmer DW and Lemeshow S. In: Applied Logistic Regression, 2nd Ed, Chapter 5, p.160--164.

[§] Galley H. Solid as a ROC. Editorial II. Br J Anaesth 2004; 93: 623--6. doi: 10.1093/bja/aeh247

6

Relationship between postoperative pain and overall 30-day complications in a broad surgical population: an observational study

Submitted and Accepted

Regina L. M. van Boekel
Michiel C. Warlé
Renske G.C. Nielen
Kris C. P. Vissers
Rob van der Sande
Ewald Bronkhorst
Jos G. C. Lerou
Monique A. H. Steegers

Abstract

Objective: The aim of this study was to establish the relationship between postoperative pain and 30-day postoperative complications.
Background: Only scarce data are available on the association between postoperative pain and a broad range of postoperative complications in a large heterogeneous surgical population.

Methods: Having postoperative pain was assessed in two ways: the movement-evoked pain score on the Numerical Rating Scale (NRS-MEP) and the patients' opinion whether the pain was acceptable or not. Outcome was the presence of a complication within 30 days after surgery. Additionally, outcome was the occurrence of one of three healthcare-associated infections (HAIs): lung infection, urinary tract infection, and surgical site infection. Multivariable logistic regression was used.

Results: In 1,014 patients the overall complication rate was 34%. The proportion of patients experiencing postoperative complications increased from 0.25 (95 % CI=0.21-0.31) for NRS-MEP=0 to 0.45 (95 % CI=0.36-0.55) for NRS-MEP=10. Patients who found their pain unacceptable had more complications (adjusted odds ratio = 2.17 (95 % CI=1.51-3.10; p<0.001)). Higher NRS-MEP scores and unacceptable pain on the first postoperative day were strongly associated with an increase in HAIs (adjusted odds ratio was 1.161 per NRS-point (95 % CI=1.055-1.279; p=0.002) and 2.49 (95 % CI=1.31-4.75; p=0.006) for unacceptable pain). Increasing age and a higher class of preoperatively expected pain independently contributed to the development of complications, including HAIs.

Conclusions: Higher actual postoperative pain scores and unacceptable pain, even on the first postoperative day, are associated with more postoperative complications, including HAIs. Further research should focus on the precise relationship between postoperative pain and the occurrence of complications per type of surgery.

Volledige artikel in te zien via:
https://www.ncbi.nlm.nih.gov/pubmed/29135493

General discussion

7

Adequate postoperative pain management is essential to keep patients comfortable, help them to quickly recover, and to prevent postoperative complications. Several authors have reported on insufficient postsurgical pain management, concluding that there is room for improvement [1, 2].
The foremost aim of the work presented in this thesis was to explore the quality of postoperative pain management in hospitals. To achieve this, we used the Donabedian model, selecting a set of factors from each of its three categories: structure, process and outcome [3].

In the discussion, we summarize our findings of seven separate studies in relation to the current situation regarding postoperative pain care, and relate these to the findings from other international research groups, providing directions for future research. We have formulated several recommendations to improve clinical practice, education and research.

Quality of care of postoperative pain management

APS teams in Dutch hospitals

The presence of an APS team in a hospital is mandatory and requested until 2006 by annual reports to the Health Care Inspectorate*. To date, no studies have been published on the organization and procedures of APS teams in the Netherlands. We therefore set up and conducted a survey, using an online questionnaire sent to all 96 Dutch hospitals performing surgical procedures (Chapter 2).
We found that 90 % of Dutch hospitals reported having an APS. The majority of APS teams are nurse based and supervised by an anesthesiologist. APS members standardly visit postoperative patients with complex pain management therapies such as regional analgesia or patient-controlled analgesia. All APS teams have educational tasks. However, 13 % of the APS teams did not participate in quality improvement projects, and nearly no APS teams were involved in pain research.
As in other countries, most APS teams in the Netherlands consist of anesthesiologists and nurses [4-6]. Patient-related activities in the Dutch APS teams are comparable with activities in APS teams in other countries. In our study sample, we found a division into two main forms of APS teams: specially dedicated and integrated dedicated teams. The first solely have duties related to APS, the latter combine APS with other duties. This second group therefore may spend less time on non-patient-related activities such as education, research and quality improvement by evaluating pain scores and making protocol adjustments; all these are generally considered important components of the APS [7-13]. These data from the Dutch hospitals indicate that most APS teams focus on direct individual patient care

* Dutch Health Care Inspectorate. Basic set for quality indicators for hospitals 2011 [cited 2012 19 May]. Available from: www.ziekenhuizentransparant.nl

without evaluating service provision at a group level. Our data also suggest that organization and procedures of APS teams in Dutch hospitals differ greatly. We note that this is similar to the situation in Germany and in the UK, where APS teams show a wide structural variation in both organization and procedures. In Germany, a recent report on the structure and processes of APS teams noted that APS teams in many hospitals are still "catheter- service" teams, like those once initiated by Ready and co-authors in 1988 [14]. In the UK, Duncan and co-workers set up the National InPatient Pain Study (NIPPS) project in 2009 [15, 16]. In this project, data from all admissions to the acute pain service of different national hospitals were digitally collected in a database. Their study revealed the wide variation in service provision of acute pain services in the UK, and related this to complex organizational and cultural barriers as well as a lack of service evaluation [15, 16].
In theory, optimally functioning APS teams should perform all patient-related and non-patient-related tasks as described by a number of authors, e.g. Rawal and co-workers and Breivik and co-workers [7-13]. Whether or not organizational differences in APS teams regarding performing these tasks influence the outcome of postoperative patients is unknown.
Now that APS teams are common in the Netherlands, further studies are needed to specify in what way these organizational differences (special versus integrated dedicated and exclusively patient-related versus non-patient-related activities included) relate to quality of care and patient outcome measures, i.e. postoperative pain intensity and complications.

Dutch Hospital Patient Safety Program: pain assessments

In 2010, the Dutch Hospital Patient Safety Program (DHPSP) was introduced in almost all Dutch Hospitals providing practice guidelines on pain assessment and pain treatment. One of the guidelines prescribed that pain should be assessed at least every eight hours and consistently documented in a patient's medical record. A few years after the program started, the question arose with regards to the extent that the DHPSP had been implemented, so we conducted two studies (Chapter 2 and 3) using different methods to answer this question. Our first study was an online survey among hospital contact persons asking for their opinion on the implementation of the DHPSP guidelines, especially with regard to pain assessment in their hospital. In the second study, we evaluated 3,895 patient records from 16 hospitals regarding the frequency of documented standardized pain assessments.

Hospitals: compliance with pain assessment is good!

In our first survey, we achieved a response rate of 83 % (Chapter 2). The hospital contact respondents indicated that almost all hospitals had pain protocols in place and that they assessed pain in surgical patients. They also reported that the DHPSP guidelines on pain assessment had been almost fully implemented. The majority of hospitals assessed movement evoked pain (MEP) as well as pain at rest (PAR)

at least three times a day. Almost half of the responding hospitals assessed pain during the entire hospitalization of the patient.
The extent of bias in self-reported outcomes of guideline implementation is known to be substantial and may produce an overestimation of performance [17]. One of the reasons is social desirability: to report socially desirable behavior when questioned even when the adherence to a social norm is not optimal. In the Netherlands, the need to adhere to the norm of the DHPSP may be great, possibly biasing the results in our study. Therefore, in the second study, we evaluated patient records concerning the frequency of documented standardized pain assessments.

Patient records: compliance with pain assessment is inadequate!

In the second study, we analyzed secondary data on the compliance with DHPSP guidelines, based on two data sources: (1) data from an evaluation study of the DHPSP, based on evaluation of patient records performed by the Netherlands Institute for Health Services Research (NIVEL); and (2) data from the digital questionnaire survey described in chapter 3. In this study, we matched data from hospitals included in both data sources. Our results show that the process indicators of DHPSP (percentage postoperative patients with ≥3 pain assessments a day, all 3 full days after surgery: 12 %), and the process indicator of the Health Care Inspectorate based on patient records (percentage postoperative patients with ≥1 pain assessment a day, all 3 full days after surgery: 53 %) and the process indicator of the Health Care Inspectorate as reported by the included hospitals (78 %), were not in line with each other.
In other countries like Canada [18] and Scotland [19], Safety Programs have been installed, however, limited or no data is available on specific themes, such as pain. Additionally, differences in assessments and the data collection method make it impossible to compare our results with those of other national programs. Therefore, we were only able to evaluate the situation in the Netherlands on this topic.
The discrepancy between reported and observed proportions of pain assessments may be partly explained by different interpretations of the definition of the process indicator of the Health Care Inspectorate. Furthermore, if pain was assessed or documented but not in a standardized manner (NRS or VAS), it was not included as an assessment in this second study, yet it could be reported as assessment to the Health Care Inspectorate. Another explanation may be the external pressure to publish the process indicator, which determines the position of the hospital on various ranking lists [20].
Our two different study designs yielded different results. Up to now, the optimal frequency of pain assessments is unclear and depends on the needs of an individual patient. Frequent assessment of pain in patients provides information enabling a decision to be made on interventions enhancing optimal pain relief [21] It is important that pain intensity is assessed regularly, using a standardized instrument [22]. Compliance with the process indicator asking for ≥1 pain assessments a day was not higher than 53 %, so this is not in line with the definition ‘assessed regularly’.

Thus there is scope to improve the nurses' adherence to pain assessment recommendations.
To develop implementation strategies, we analyzed whether hospital characteristics or APS characteristics influenced the compliance of health professionals with the guidelines on pain assessment. The analysis is discussed in the following section.
To conclude from both studies, we were able to show that it is not sufficient only to ask for implementation progression, but that data on the exact methods of pain assessment and documentation is also necessary. Feedback on these processes may help further improve adherence to pain assessment. Further research should focus on a multifaceted implementation strategy, addressing good education on the importance of pain assessment itself, the disappearance of organizational barriers, and feedback on personal performance of nurses [23].

Surgery shows best compliance with pain assessment!

In our second study, we also investigated whether hospital characteristics or APS characteristics influence the compliance of health professionals with the pain assessment guidelines (Chapter 3). We found that type of hospital and type of department influenced the compliance with postoperative pain assessment. Based on patient records, general hospitals reported a better compliance with pain assessments, both regarding ≥3 pain assessments a day and ≥1 pain assessment a day (11 % and 59 % respectively) compared to tertiary teaching (2 % and 27 % respectively) and academic hospitals (7 % and 56 % respectively). Between departments, compliance was relatively high for patients admitted to the surgical oncology department and to the surgery and orthopedics departments, compared to other departments.
APS factors were not associated with the compliance with pain assessment, except for the presence of a training program by the APS for nurses and/or physicians. Those hospitals had a lower compliance with pain assessment.
Studies on compliance with pain assessment are scarce. In a study by Nicholas and co-workers investigating hospital process compliance and surgical outcomes, the researchers determined whether high rates of compliance with perioperative process of care measures used for public reporting and pay-for-performance were associated with lower rates of risk-adjusted mortality and complications with high-risk surgery [24]. They found that process compliance ranged from 54 % in low compliance hospitals to 91 % in the highest, supporting differences between hospitals in compliance with perioperative process indicators [24]. Other factors, however, might play a role in the varying compliance, for example hospital or department culture, priorities of the organization, education possibilities or research; these were not studied [25].
The higher compliance for assessing pain in patients admitted to the surgical oncology department and to the surgery and orthopedics departments compared to the other departments may be explained by the relatively high percentage of patients with pain in these departments [26, 27]. It is likely that assessing pain in these

departments has greater priority, be part of the daily routine, and embedded in ward-specific protocols of these medical specialties. This finding is supported by a study by Chang and co-workers investigating pain management in medical wards in the United Kingdom. They found that pain was assessed in the medical wards in only 18 % of the hospitals [28]. One of the reasons was that time and staff shortages in some hospitals meant that many APS teams were only just coping with the management of acute pain in surgical patients, leaving few resources for medical patients. In another study on pain assessment in different wards of a tertiary care hospital, Anwar-ul-Huda and co-workers showed that regular pain assessment was performed for all the patients in the surgical ward and was also reasonably good in the emergency room (60 %) but much lower (24 %) in the medical ward. The authors concluded that this was probably because the surgical ward was managed by a team of the Acute Pain Management Service [29].

Since the presence of APS teams may enhance postoperative pain management, it is not clear why hospitals with an APS training program for nurses and/or physicians in our study had a lower compliance on pain assessment. Education of nurses in pain management has been shown to improve nurses' knowledge of pain, leading to a better compliance to guidelines on pain management [30]. Additionally, pain education may be organized in various ways. Hospitals with no APS training programs could have a hospital-wide program whereby the hospital takes responsibility for the training course, and possibly more personnel could therefore be trained in pain management. Successful use of guideline recommendations in clinical practice not only depends on education alone, but on the availability of staff and time, cooperation with other professionals, and attitudes of personnel [31-33]. Implementation is influenced by the attitude of nurses and doctors, so that a negative attitude toward pain assessment and treatment forms a barrier to implementing practice change [34]. Compliance may also decrease if the interval between periodical training is too long [35]. In our studies, we did not record information about participation, experiences with, and duration of the training.

A high compliance to postoperative pain guidelines is often seen as the way to improve the outcome of pain management after surgery [36]. However, a study by Nicholas and co-workers showed that a high compliance with perioperative process indicators did not automatically mean that the chance of complications after surgery was reduced [24]. Nevertheless, as discussed earlier, future research should focus on multifaceted implementation strategies to improve the nurses' adherence to pain assessment while taking into account different influencing factors. Furthermore, the role of APS teams in medical wards should be investigated and the relationship between the compliance with pain assessment and patient outcomes needs to be addressed.

High prevalence of moderate to severe postoperative pain in surgical patients!

Several studies describe a high overall prevalence of moderate to severe postoperative pain in surgical patients, also in the Netherlands [1, 2, 37-39]. These figures range from 41 %-65 % patients, and are more or less constant over time [15, 40].
We therefore conducted two studies to investigate the prevalence of pain in our hospital, as well as the incidence of complications. The first study was performed on prospectively collected pain assessments of patients following major surgery (Chapter 4). The second study was performed on data of a prospectively recruited cohort of patients undergoing a broad range of surgical procedures (Chapter 6).
Our first study showed that the overall percentage of patients with moderate to severe pain on day 1-4 after surgery based on movement evoked numerical rating scale pain (NRS-MEP) scores were 50.3 % and 9.2 % respectively. In the second study, 39.2 % and 15.8 % of the patients reported moderate to severe pain respectively on day one after surgery; 37.0 % and 10.2 % on day two; and 32.1 % and 6.3 % on day 3. Overall, 16.8 % of the patients reported unacceptable pain on one of the first three postoperative days. In a Dutch study conducted in 2008, moderate or severe pain after surgery was reported by 41 % of the patients on day 0, 30 % on day 1, 19 % on day 2, 16 % on day 3, and 14 % on day 4 [2]. These percentages are comparable with other studies on the prevalence of postoperative pain [1, 37, 41].
Although studies differ in research methodology, such as the choice of pain measurement tool, the definition of moderate or severe pain and the time frame of observation, all studies show that the number of patients experiencing moderate to severe pain remains high. This suggests that there is great room for improvement. We need to find out more about the differences between those patients who recover quickly and without any complications and those who, after a number of days, still have moderate or severe pain and those who develop complications.
Reducing the prevalence of moderate to severe postoperative pain may be possible by implementing personalized procedure specific pain treatment. Several risk factors for the development of postoperative pain have been identified, such as gender, age, type of surgery, anxiety, pain catastrophizing and preoperative chronic pain intensity [42-44]. In a recent multicenter study, Guntinas-Lichius and co-workers noted inter-hospital variability of pain after tonsillectomy, claiming that other extrinsic factors influence the pain experience [45]. These may include hospital-related parameters like availability of APS teams and protocols, staff training, environmental influences, and factors like dedication and empathy of doctors and nurses. Personalized procedure specific pain treatment may be possible when all known risk factors contributing to the patient's personal pain experience are taken into account preoperatively and used to balance treatment options [46, 47].
Another patient-related factor is the patients' ability to accept pain. In our second study, only 16.8 % of patient found the pain to be unacceptable on day 1-3 after surgery, despite the high prevalence based on NRS-MEP scores. Therefore, inter-individual and inter-hospital variability in postoperative pain experience need

to be further explored in order to improve postoperative pain management for the individual patient.

Regional anesthesia superior to PCIA!

One factor of hospital variability is the hospital protocol on pain treatment after different surgical procedures. We performed a study on prospectively collected pain data of patients after major surgery to investigate whether regional anesthesia provided superior pain relief compared to patient-controlled intravenous analgesia in patients undergoing abdominal surgery, thoracotomy, and extremity surgery (Chapter 4). Although there was a great variation in pain scores, results showed that those patients who received regional anesthesia reported lower pain scores than those who received patient controlled intravenous analgesia (PCIA), after undergoing the same surgical procedures. Additionally, pain at rest (PAR) scores were significantly lower than MEP scores.

Srikandarajah and co-workers estimated the frequency of reported MEP scores versus reported PAR scores in postsurgical clinical trials and meta-analyses [48]. They found that MEP is generally more severe in intensity than PAR [48]. Furthermore, MEP has an adverse impact on surgical site-related physiological function [49], and that interventions resulting in less severe MEP were associated with fewer postoperative thrombo-embolic and pulmonary complications [50, 51]. MEP adversely impacts upon patient ambulation and functional recovery in the early postoperative period [52]. They recommended that MEP should be assessed and reported as outcome in every postsurgical trial. We also noted the difference between MEP scores and PAR scores in our study, so we strongly support this statement and used the NRS-MEP in our next studies.

Although there were large variations in pain scores, results of our study showed that patients who received regional anesthesia reported lower pain scores than those who received PCIA. Pöpping and co-workers reviewed the data of 18,925 patients who had undergone major surgery on the quality of pain relief, major complications, and adverse effects [53]. They also reported that regional anesthesia was superior to PCIA. Furthermore, they noted that close supervision of these techniques by an APS team in the postoperative period is mandatory, as they are potentially dangerous if not applied professionally. In a study by Guntinas-Lichius and co-workers, inter-hospital variability of postoperative pain scores was reported. As shown in our study, different pain treatment techniques for the same surgical procedures in different hospitals may be one of the causes of this variation [45].

The large variability on pain scores highlights the personal experience of pain as being something greater than tissue damage triggering a response from the nervous system, and that it is influenced by several other factors. Therefore, as stated in the previous section, future research should focus on personalized pain assessment and pain treatment to improve clinical practice for the individual patient.

One in five patients accept their pain and show normal physical activities even with high pain scores!

In the clinical setting, patients may report a high MEP, yet claim their pain is acceptable. Van Dijk and co-workers showed that some patients and pain professionals interpret pain scores differently [54]. We therefore conducted a study to quantify relationships between NRS and other methods of pain assessment, such as the patients' willingness to accept pain and the functional capacity.
In this study (Chapter 5) we found that low pain scores do not always mean that patients find their pain acceptable. Nor do high pain scores necessarily mean that patients find their pain unacceptable. Approximately one in ten patients reported a low NRS-MEP of 0, 1, 2, 3 or 4, but had unacceptable pain. Despite a high pain score of NRS-MEP=7, at least one in five patients were willing to accept their pain and, at the same time, perform the required physical activities. Therefore, we can conclude that caregivers, in order to make adequate clinical decisions, should use multidimensional assessments of pain, and move beyond the sole use of cut-off points on the NRS.
Although ours was the first study to quantify the relationships between NRS-MEP and acceptability of pain, functional impact of pain, and a measure combining the two as a clinically desirable situation, other authors have found similar results.
Van Dijk and co-workers reported that many patients with a high pain score did not want to use opioids when having a high pain score, because they considered their pain "tolerable" [55]. They concluded that patients have a different view on NRS cut-off scores; many patients consider NRS scores 4, 5 and 6 as bearable, and prefer not to take analgesics [21]. Maroney and co-workers observed that 31 % of 1,249 patients who reported severe pain on a four-item scale, found their pain acceptable [56].
To fully estimate patients' experience of pain, a single NRS score alone is not sufficient for decision-making. To balance treatment options, other dimensions of pain should be assessed [57, 58]. A combination of patient opinion and nurse observation is a requirement when communicating with the patient, as this results in a better understanding of the particular pain score without being judgmental [21].
Our study did not include outcome data, so no effect could be measured of the multidimensional pain assessment. Future research should therefore focus on pain-related outcomes in relation to multidimensional pain assessment and treatment decisions.

Postoperative complications directly related to postoperative pain!

In recent years, reports of inadequate management of acute postoperative pain have suggested that postoperative pain is associated with severe effects on patient outcomes, delaying the patients' physical recovery after surgery, as well as reducing quality of life [38, 59].
Results from our study on the relationship between postoperative pain and

complications after surgery (Chapter 6) show that postoperative pain may contribute to the occurrence of complications after surgery. We showed that one third (33.8 %) of postoperative patients experienced some type of complication. Additionally, complications after surgery were positively associated with the actual postoperative pain, the expected pain, as well as with age. Furthermore, subgroup analysis showed that healthcare-associated infections after surgery were positively associated with the actual pain on the first postoperative day, the expected pain and age.

We found a relatively high complication rate. This overall complication rate is comparable with several other studies in this field, for example Mayo and co-workers reported on colorectal surgery (37.0 %) [60], Ghaferi and co-workers on major operations (36.4 %) [61] and Makary and co-workers on frailty and complications (up to 43.5 %) [62]. However, the complication rate in our study is much higher than that found in three other studies in which all surgery was included (10.8 % [63], 11.0 % [64], and 16.4 % [65]. We propose three reasons for our high complication rate: (1) our study was conducted at a university hospital where patients with more complex diagnoses requiring more complex care are treated compared to general hospitals, (2) complications were retrieved from full digital medical records in which all hospital- based medical history of the patients was filed, and (3) it is difficult to compare complication rates between studies due to methodological differences such as definitions, quantity or methods of documentation [66, 67].

We showed an association between the occurrence of complications after surgery and having postoperative pain, with analyses of NRS-MEP, as well as with a separate acceptability question on whether the postoperative pain was acceptable or not. We argue that there is a causal relationship however this is not proven; in theory, patients may simply have more pain because a complication is present [68]. However, the association we found between having postoperative pain on the morning of the first postoperative day and the occurrence of healthcare-associated infections (HAIs) strongly supports the theory that postoperative pain contributes to developing complications. It is unlikely that HAIs present themselves on the first morning after surgery. However, we can state that both less postoperative pain and/or less complications after surgery would be beneficial for patients.

Our results suggest that the quality of acute postoperative pain management can be improved by the awareness of early detection and treatment of postoperative pain. Even though we do not understand the exact relationship between postoperative pain intensity and complications, and whether adequate postoperative pain management prevents HAIs, we can state that postoperative pain is a good indicator of future complications.

One limitation of our study was the retrospective grading of complications because of potentially incomplete reporting during routine clinical care. Future research should focus on the early detection of pain and complications in a full prospective study.

Critical analysis of the research methodology

A great strength of our studies on APS teams presented in Chapters 2 and 3 was the high response rate of the national survey (83 %), resulting in an accurate overview of the Dutch APS teams. The two studies performed using the consecutive patient data gathered during five years of clinical practice of the APS, the study on regional anesthesia versus patient controlled intravenous analgesia presented in Chapter 4, and the study on the relationship between NRS and other methods of pain assessment reported in Chapter 5, were based on clinically collected real-time documentation of patient consultations of more than 9,000 patients who underwent major surgery. These data give a realistic valuable reflection of clinical practice.
A strong point of our study on the relationship between postoperative pain and complications noted in Chapter 6 was the inclusion of a patient mix of many surgical specialties and types of surgery, with or without co-morbidities, as a representation of real-world clinical practice. Another strong point was that the medical researchers searching for and grading complications were not involved with the care of the patient because of the retrospective character of their activities. It is conceivable that in a prospective study, the ongoing research and the researchers' activities could lead to improvements in the quality of patient care.

However, we have to address a number of limitations with regard to the research we conducted. In chapter 2, we report on an investigation of the existence, structure and responsibilities of the Dutch APS teams in hospitals and the degree of implementation of the Dutch Hospital Patient Safety Program. All hospitals in the Netherlands were approached with a survey about acute pain management in their hospital. Although this research design is frequently used, when using self-completion questionnaires it is not entirely clear if the answers reflect the real clinical situation in a hospital.
In our study presented in chapter 3, we noted a difference in the number of pain measurements observed in patient files compared to the number of pain assessments that the contact persons claimed to be executed in their hospitals. This difference seems to imply that the information provided by the contact persons was not reliable. In the future, research evaluations of the quality of acute pain management in hospitals should ideally be performed by site visits instead of surveys [17].
Furthermore, when investigating quality of pain management after surgery, preferably all characteristics of patients, hospitals and APS teams as well as outcome measures need to be considered in order to draw reliable conclusions.
In chapter 6, we reported on our study on the association of postoperative pain and complications after surgery. Prospective randomized controlled trials on this topic confirming causality are neither possible or ethically approved. Therefore, we retrospectively collected complications after surgery from the patient files.

Depending on the administration of clinical findings, we found that patient reports were not filled in consistently. In order to reduce costs and improve clinical value, we suggest performing large prospective observational studies of clinically collected data. In order to do so, we need to introduce uniform reporting methods and digital patient files, with the ability to retrieve data easily. Therefore, in the future, a study on uniform reporting of complications in digital patient files should be conducted.

General conclusions and recommendations

General conclusions

In this thesis we present the results of seven separate studies: (1) a description of the Dutch APS teams in hospitals, (2) an analysis of the compliance with pain assessment in postoperative patients after implementation of the Dutch Hospital Patient Safety Program and influencing factors, based on information of hospital contact respondents and based on patient records, (3) a description of the prevalence of acute postoperative pain in a tertiary high academic hospital setting in the Netherlands, (4) an analysis of the outcome of different pain management techniques after major surgery, (5) an analysis of the association between several components of pain assessment, and (6) an analysis of the association between unacceptable postoperative pain and complications after surgery.

This has led to a description of factors that determine the quality of care of postoperative pain management. Currently, there is a good understanding of the interrelationship between the factors in the three categories: “structure,” “process,” and “outcome” [3] as shown in the quality circle of postoperative pain management derived from Donabedian’s quality of care framework [22, 39, 59].

Our results demonstrate that postoperative pain management can be improved by (1) optimizing APS teams, (2) performing frequent multidimensional pain assessments and by (3) evaluating outcome measures including postoperative complications. Using the Donabedian model, we have shown that the structure, the process, as well as the outcome of postoperative pain management are interrelated factors. In order to improve postoperative pain management, all the influencing factors need to be addressed. Therefore, a hospital-wide improvement program is necessary which reviews the role of APS teams and other professionals, and focuses on the improvement of adherence to multidimensional pain assessment and the evaluation of pain treatment according to the Plan-Check-Do-Act cycle (PDCA cycle) [69]. The program evaluation should include measures of the intensity of the pain, the patient’s opinion on the acceptability of the pain, the observation of physical function, and the development of complications after surgery.
In addition to the recommendations made in this thesis, some conditions are inseparably connected with quality improvement. The Board of Directors of

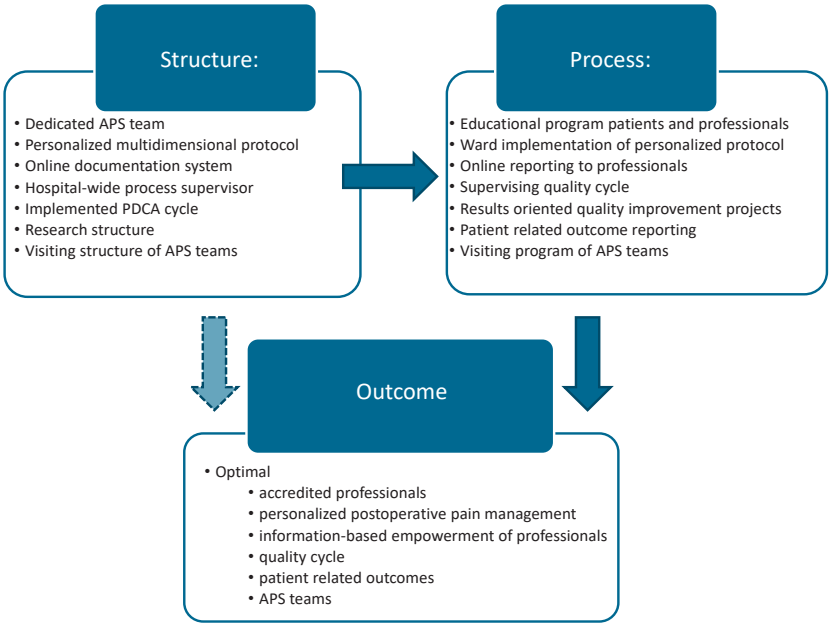

Figure 1 Donabedian's quality of care framework of postoperative pain
Donabedian's quality of care framework of postoperative pain management shows the recommendations for improving the quality of pain management after surgery, classified under three categories "structure", "process", and "outcome".

a hospital needs to approve investments in a dedicated APS team, in ICT with possibilities for adequate data analyses, and in a hospital-wide process coordinator for the supervision of the implementation and maintenance of multidimensional pain assessment and pain treatment by quality improvement projects.
The conclusions and recommendations presented in this thesis can be used to assess the situation in the reader's own hospital to improve the organization of postoperative pain management.

Connecting our results to the Donabedian model

By completing the Donabedian framework for postoperative pain management, we connected our findings with those from previous studies, as shown in Figure 1 of the Introduction. This has enabled us to make several recommendations and to develop a comprehensive overview to be used as a quality cycle for improving the quality of postoperative pain management.

In Figure 1, we have summarized the recommendations in Donabedian's quality of care framework of postoperative pain management. The detailed recommendations are described in Tables 1-3.

Recommendations for clinical practice

Acute Pain Service

Although there is currently no consensus on the organization, staffing or requirements for qualitative APS teams [70], the main components of an APS should include the following: (1) designated personnel responsible for 24-hour APS (in small hospitals 1 or 2 individuals may suffice), (2) regular multidimensional pain assessment at rest and movement, maintaining pain scores below predetermined individual threshold level, and documentation ("make pain visible"), with appropriate scales for children and patients with cognitive impairment, (3) active cooperation with physicians and ward nurses for developing protocols and critical pathways to achieve preset goals for mobilization and rehabilitation, (4) ongoing teaching programs for ward nurses and physicians for the provision of safe and cost-effective analgesic techniques, (5) patient education regarding pain monitoring and treatment options, goals, benefits and adverse effects, and (6) regular analysis of pain intensity and complications and an audit of cost-effectiveness of analgesic techniques on surgical and medical wards and patient satisfaction of both inpatients and day case patients [12].

We propose that APS teams should invest in patient care as well as in non-patient-related activities as recommended above, enhancing organizational postoperative pain management. It would be ideal for all APS teams to evaluate the outcome of all postoperative patients in their hospital for procedure-specific optimized pain management. Creating the research structure, time and ambiance to analyze patient data is essential. Evaluating real patient data collected on every patient visit is important for further improvement of the quality of postoperative pain management, because this information is crucial to identifying problems in the implementation process [15]. APS teams should take the lead in a multifaceted implementation strategy to advance pain assessment and pain treatment. To avoid high costs and workload, the large datasets should be created as part of the clinical process. Tailored educational programs for ward personnel as well as patients are also important and need to be organized by APS teams. The way forward may require organizational changes to the APS teams so that they can fulfil all tasks appropriately. Site visits by well-functioning APS teams may be valuable in initiating the upgrading of other APS teams.

Pain assessment

Frequent assessment of pain in patients provides information enabling decisions to be made on interventions enhancing optimal pain relief [21]. It is important that pain intensity is assessed regularly, using a standardized instrument [22]. Studies conducted in this thesis have shown that pain is not assessed regularly in all hospitals; adherence to pain assessment in hospital needs improving. Therefore, result-oriented quality improvement projects addressing pain assessment are recommended. A hospital-wide process supervisor, connected with the APS team needs to implement and maintain improvements and facilitate organizational changes. When assessing pain, health professionals need to be aware of the

multidimensional aspect of postoperative pain and thus use a multidimensional instrument. The combination of NRS pain score and the patients' opinion on the acceptability of the pain as well as the nurses' observation of the functional impact of the pain can be used for this purpose. Furthermore, decisions on pain treatment need to be taken based on the multidimensional pain assessment and in accordance with multidimensional personalized protocols, set up with the patient.

Pain intensity and complications

Complications after surgery occurred more often in patients with postoperative pain. Whether or not a causal relationship is present, postoperative complications developed need to be evaluated in order to identify barriers and limitations in perioperative care, including postoperative pain management. After surgery, every patient should be closely monitored and data registered in an easily accessible

Table 1 Recommendations for clinical practice following the results presented in this thesis

A:	**Concerning the organization and responsibilities of APS teams in hospitals**
1.	Install dedicated APS team outreaching from the Department of Anesthesiology with hospital-wide responsibilities.
2.	Stipulate that this APS team has patient-related and non-patient-related tasks.
3.	Organize a multifaceted implementation project concerning pain assessment and pain treatment, addressing good education on the importance of pain assessment itself, the disappearance of organizational barriers, and feedback on personal performance of health professionals.
B:	**Concerning pain assessment in hospitals**
1.	Make a preoperative pain treatment plan accounting for known risk factors for the development of postoperative pain.
2.	Assess pain in patients using a multidimensional assessment tool which includes a pain score at rest and in movement, a question on the acceptability of the pain, and a tool to observe physical functioning.
3.	Define a personal treatment threshold with the patient.
4.	Assess pain in patients regularly, preferably three times but at least once every day during admission time.
5.	Make pain treatment decisions based on a multidimensional pain assessment including the patient's perception.
6.	Avoid using a predefined cut-off point to decide on pain treatment.
7.	Evaluate and adjust pain treatment including the patient's perception.
C:	**Concerning postoperative pain intensity and complications after surgery in hospitals**
1.	Evaluate pain intensity, acceptability of pain and functional capacity in individual patients as well as in groups of patients to identify obstacles concerning adequate analgesia.
2.	Evaluate complications in individual patients as well as in groups of patients to identify obstacles concerning adequate analgesia.
3.	Set up quality improvement projects to solve identified obstacles.
4.	Adjust current pain practices to achieve excellent postoperative pain management.

electronic patient file regarding the development of postoperative pain and complications. Evaluations should be performed at patient and group level to identify the barriers to and limitations of excellent pain management. Quality improvement projects should be developed to overcome these problems to improve the quality of care for current as well as for future patients.
Table 1 summarizes the recommendations for clinical practice.

Recommendations for education

As we have described several recommendations for clinical practice in the previous section, it will be necessary to provide education programs for all health professionals working with patients perioperatively. This may start directly from when patients are referred to surgical specialists by the general practitioner. Very little or fragmented education on pain management is given at medical school or even in basic nursing education.
Physicians and nurses working with surgical patients may need regular updates on patient education, and on how to perform pain assessment adequately in order to balance treatment options, including patient perceptions.
APS teams play an important role in educating other health professionals in pain management. The APS teams themselves should invest in expanding their role according to the recommended patient-related and non-patient-related tasks of APS teams, and to ensure they acquire the competencies needed to fulfil this role.

Table 2 Recommendations for education following the results presented in this thesis

A:	**Concerning the organization and responsibilities of APS teams in hospitals**
1.	Educate members of APS teams to fulfil APS activities in accordance with the recommended patient-related and non-patient-related tasks.
2.	Educate all health professionals working with surgical patients to digitally document patient data concerning postoperative pain management in the corresponding system.
B:	**Concerning pain assessment in hospitals**
1.	Educate patients in pain and pain assessment and the importance of treating postoperative pain.
2.	Educate all health professionals involved in peri-operative care in postoperative pain management, addressing patient education, known risk factors for the development of postoperative pain, and the importance of treating and evaluating postoperative pain based on regular multidimensional pain assessments, including the patient's perception.
C:	**Concerning postoperative pain intensity and complications after surgery in hospitals**
1.	Use data on pain intensity, acceptability of pain, functional capacity and complications on a patient level as well as aggregated data at group level to teach all health professionals involved in peri-operative care in postoperative pain management.
2.	Teach all health professionals involved in peri-operative pain assessment to look beyond a predefined protocol cut-off score for pain treatment, and define a personal treatment threshold with the patient.

Table 2 summarizes the recommendations for education.

Recommendations for research

Research should be conducted on the organizational process of postoperative pain management in the reader's own hospital, for example analysis of patient-reported outcomes, the online reporting of these findings to professionals, as well as organizing a visiting program of APS teams.
Our findings have led to several new research questions. First, some APS characteristics need to be investigated for their influence on the adherence to pain assessment. More research is needed to explore which APS characteristics allow the best pain intensity and functional outcome in patients. Second, we

Table 3 Recommendations for research following the results presented in this thesis

A:	**Concerning the organization and responsibilities of APS teams in hospitals**
1.	Create a research structure, time and awareness in APS teams and the Department of Anesthesiology, hosting APS teams.
2.	Organize a system, including a research structure in which prospective clinically collected digital real-time documentation of postoperative pain management, including complications after surgery is facilitated.
3.	Organize a visiting program of APS teams.
4.	Investigate which patient-related and non-patient-related activities of APS teams influence the pain intensity, acceptability of pain, and functional capacity of postoperative patients, and their recovery by site visits, including all known influential factors.
5.	Investigate the role of APS teams in medical wards.
B:	**Concerning pain assessment in hospitals**
1.	Organize a regular data-analysis process.
2.	Set up new quality improvement projects based on results of data-analysis of hospital-wide patient-related outcome.
3.	Evaluate and adjust the multifaceted implementation strategy concerning pain assessment and pain treatment based on results of data-analysis.
4.	Report results of data-analysis to health care professionals.
5.	Investigate pain-related outcomes in relation to multidimensional pain assessment and treatment decisions.
C:	**Concerning postoperative pain intensity and complications after surgery in hospitals**
1.	Investigate the outcome of all postoperative patients in the hospital to optimize procedure-specific pain management.
2.	Investigate the inter-individual and inter-hospital variability in postoperative pain experience of patients, with the ultimate goal of personalized pain management.
3.	Create a system in which outcome data are reported regularly to clinicians, based on patient-related outcomes.

show that the adherence to pain assessment needs to be improved and that multidimensional pain assessment is important. More research is needed on a multi-faceted implementation strategy for multidimensional pain assessment. Third, the inter-individual and inter-hospital variability in postoperative pain experience of patients and pain-related outcomes should be investigated in order to perform personalized pain management.

Table 3 summarizes our recommendations for research.
To conclude: to improve the quality of current postoperative pain management, it is imperative for hospitals and APS teams to increase the attention paid to postoperative pain in patients and the implementation of the recommendations made above, according to Donabedian's quality of care framework of postoperative pain management.

References

1. Apfelbaum JL, Chen C, Mehta SS, Gan TJ. Postoperative pain experience: results from a national survey suggest postoperative pain continues to be undermanaged. Anesthesia and analgesia. 2003;97(2):534-40, table of contents.
2. Sommer M, de Rijke JM, van Kleef M, Kessels AG, Peters ML, Geurts JW, et al. The prevalence of postoperative pain in a sample of 1490 surgical inpatients. European journal of anaesthesiology. 2008;25(4):267-74.
3. Donabedian A. The quality of care. How can it be assessed? JAMA. 1988;260(12):1743-8.
4. Stamer UM, Mpasios N, Stuber F, Maier C. A survey of acute pain services in Germany and a discussion of international survey data. Regional anesthesia and pain medicine. 2002;27(2):125-31.
5. Powell AE, Davies HT, Bannister J, Macrae WA. Rhetoric and reality on acute pain services in the UK: a national postal questionnaire survey. British journal of anaesthesia. 2004;92(5):689-93.
6. Nasir D, Howard JE, Joshi GP, Hill GE. A survey of acute pain service structure and function in United States hospitals. Pain research and treatment. 2011;2011:934932.
7. Bardiau FM, Taviaux NF, Albert A, Boogaerts JG, Stadler M. An intervention study to enhance postoperative pain management. Anesthesia and analgesia. 2003;96(1):179-85, table of contents.
8. Breivik H. How to implement an acute pain service. Best practice & research Clinical anaesthesiology. 2002;16(4):527-47.
9. Rawal N. Organization, function, and implementation of acute pain service. Anesthesiology clinics of North America. 2005;23(1):211-25.
10. Shapiro A, Zohar E, Kantor M, Memrod J, Fredman B. Establishing a nurse-based, anesthesiologist-supervised inpatient acute pain service: experience of 4,617 patients. Journal of clinical anesthesia. 2004;16(6):415-20.
11. Harmer M, Davies KA. The effect of education, assessment and a standardised prescription on postoperative pain management. The value of clinical audit in the establishment of acute pain services. Anaesthesia. 1998;53(5):424-30.
12. Rawal N. Acute pain services revisited--good from far, far from good? Regional anesthesia and pain medicine. 2002;27(2):117-21.
13. Karlsten R, Strom K, Gunningberg L. Improving assessment of postoperative pain in surgical wards by education and training. Quality & safety in health care. 2005;14(5):332-5.
14. Ready LB, Oden R, Chadwick HS, Benedetti C, Rooke GA, Caplan R, et al. Development of an anesthesiology-based postoperative pain management service. Anesthesiology. 1988;68(1):100-6.
15. Duncan F, Day R, Haigh C, Gill S, Nightingale J, O'Neill O, et al. First steps toward understanding the variability in acute pain service provision and the quality of pain relief in everyday practice across the United Kingdom. Pain medicine. 2014;15(1):142-53.
16. McDonnell A, Wilson R, Goodacre S. Evaluating and implementing new services. Bmj. 2006;332(7533):109-12.
17. Adams AS, Soumerai SB, Lomas J, Ross-Degnan D. Evidence of self-report bias in assessing adherence to guidelines. International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua. 1999;11(3):187-92.
18. Canadian Patient Safety Institute. Safer Healthcare Now! 2016. Available from http://www.patientsafetyinstitute.ca/en/About/Programs/SHN/Pages/default.aspx (accessed 25 August 2016)
19. Scottish Patient Safety Programme. Programmes 2016. Available from http://www.scottishpatientsafetyprogramme.scot.nhs.uk/ (accessed 25 August 2016)
20. Van Boekel RLM, Steegers MAH, De Blok C, Schilp J. Pain registration: for the benefit of the inspectorate or the patient? Ned Tijdschr Geneeskd. 2014;158:A7723.
21. van Dijk JF, Vervoort SC, van Wijck AJ, Kalkman CJ, Schuurmans MJ. Postoperative patients' perspectives on rating pain: A qualitative study. International journal of nursing studies. 2016;53:260-9.
22. Meissner W, Coluzzi F, Fletcher D, Huygen F, Morlion B, Neugebauer E, et al. Improving the management of post-operative acute

pain: priorities for change. Current medical research and opinion. 2015;31(11):2131-43.
23. Ista E, van Dijk M, van Achterberg T. Do implementation strategies increase adherence to pain assessment in hospitals? A systematic review. International journal of nursing studies. 2013;50(4):552-68.
24. Nicholas LH, Osborne NH, Birkmeyer JD, Dimick JB. Hospital process compliance and surgical outcomes in medicare beneficiaries. Archives of surgery. 2010;145(10):999-1004.
25. van Boekel RL, Steegers MA, de Blok C, Schilp J. [Pain registration: for the benefit of the inspectorate or the patient?]. Nederlands tijdschrift voor geneeskunde. 2014;158:A7723.
26. van den Beuken-van Everdingen MH, de Rijke JM, Kessels AG, Schouten HC, van Kleef M, Patijn J. High prevalence of pain in patients with cancer in a large population-based study in The Netherlands. Pain. 2007;132(3):312-20.
27. Thomazeau J, Rouquette A, Martinez V, Rabuel C, Prince N, Laplanche JL, et al. Predictive Factors of Chronic Post-Surgical Pain at 6 Months Following Knee Replacement: Influence of Postoperative Pain Trajectory and Genetics. Pain physician. 2016;19(5):E729-41.
28. Chang SH, Maney KM, Mehta V, Langford RM. Pain assessment and management in medical wards: an area of unmet need. Postgraduate medical journal. 2010;86(1015):279-84.
29. Anwar ul H, Hamid M, Baqir M, Almas A, Ahmed S. Pain assessment and management in different wards of a tertiary care hospital. JPMA The Journal of the Pakistan Medical Association. 2012;62(10):1065-9.
30. McNamara MC, Harmon D, Saunders J. Effect of education on knowledge, skills and attitudes around pain. British journal of nursing. 2012;21(16):958, 60-4.
31. Clark M. Barriers to the implementation of clinical guidelines. Journal of tissue viability. 2003;13(2):62-8.
32. Meesterberends E, Wilborn D, Lohrmann C, Schols JM, Halfens RJ. Knowledge and use of pressure ulcer preventive measures in nursing homes: a comparison of Dutch and German nursing staff. Journal of clinical nursing. 2014;23(13-14):1948-58.
33. Moore Z, Price P. Nurses' attitudes, behaviours and perceived barriers towards pressure ulcer prevention. J Clin Nurs. 2004;13(8):942-51.
34. Shaban RZ, Holzhauser K, Gillespie K, Hucksson S, Bennetts S. Characteristics of effective interventions supporting quality pain management in Australian emergency departments: an exploratory study. Australasian emergency nursing journal : AENJ. 2012;15(1):23-30.
35. De Rond M, de Wit R, van Dam F. The implementation of a Pain Monitoring Programme for nurses in daily clinical practice: results of a follow-up study in five hospitals. Journal of advanced nursing. 2001;35(4):590-8.
36. Chou R, Gordon DB, de Leon-Casasola OA, Rosenberg JM, Bickler S, Brennan T, et al. Management of Postoperative Pain: A Clinical Practice Guideline From the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. The journal of pain : official journal of the American Pain Society. 2016;17(2):131-57.
37. Dolin SJ, Cashman JN, Bland JM. Effectiveness of acute postoperative pain management: I. Evidence from published data. British journal of anaesthesia. 2002;89(3):409-23.
38. Wu CL, Naqibuddin M, Rowlingson AJ, Lietman SA, Jermyn RM, Fleisher LA. The effect of pain on health-related quality of life in the immediate postoperative period. Anesthesia and analgesia. 2003;97(4):1078-85, table of contents.
39. Wu CL, Raja SN. Treatment of acute postoperative pain. Lancet. 2011;377(9784):2215-25.
40. Correll DJ, Vlassakov KV, Kissin I. No evidence of real progress in treatment of acute pain, 1993-2012: scientometric analysis. Journal of pain research. 2014;7:199-210.
41. Gan TJ, Habib AS, Miller TE, White W, Apfelbaum JL. Incidence, patient satisfaction, and perceptions of post-surgical pain: results from a US national survey. Current medical research and opinion. 2014;30(1):149-60.
42. Gerbershagen HJ, Pogatzki-Zahn E, Aduckathil S, Peelen LM, Kappen TH, van Wijck AJ, et al. Procedure-specific risk factor analysis for the development of severe postoperative pain. Anesthesiology. 2014;120(5):1237-45.
43. Pinto PR, McIntyre T, Almeida A, Araujo-Soares V. The mediating role of pain cata-

strophizing in the relationship between presurgical anxiety and acute postsurgical pain after hysterectomy. Pain. 2012;153(1):218-26.
44. Gerbershagen HJ, Dagtekin O, Rothe T, Heidenreich A, Gerbershagen K, Sabatowski R, et al. Risk factors for acute and chronic postoperative pain in patients with benign and malignant renal disease after nephrectomy. European journal of pain. 2009;13(8):853-60.
45. Guntinas-Lichius O, Geissler K, Komann M, Schlattmann P, Meissner W. Inter-Hospital Variability of Postoperative Pain after Tonsillectomy: Prospective Registry-Based Multicentre Cohort Study. PloS one. 2016;11(4):e0154155.
46. Janssen KJ, Kalkman CJ, Grobbee DE, Bonsel GJ, Moons KG, Vergouwe Y. The risk of severe postoperative pain: modification and validation of a clinical prediction rule. Anesthesia and analgesia. 2008;107(4):1330-9.
47. Kalkman CJ, Visser K, Moen J, Bonsel GJ, Grobbee DE, Moons KG. Preoperative prediction of severe postoperative pain. Pain. 2003;105(3):415-23.
48. Srikandarajah S, Gilron I. Systematic review of movement-evoked pain versus pain at rest in postsurgical clinical trials and meta-analyses: a fundamental distinction requiring standardized measurement. Pain. 2011;152(8):1734-9.
49. Vassilakopoulos T, Mastora Z, Katsaounou P, Doukas G, Klimopoulos S, Roussos C, et al. Contribution of pain to inspiratory muscle dysfunction after upper abdominal surgery: A randomized controlled trial. American journal of respiratory and critical care medicine. 2000;161(4 Pt 1):1372-5.
50. Modig J, Borg T, Karlstrom G, Maripuu E, Sahlstedt B. Thromboembolism after total hip replacement: role of epidural and general anesthesia. Anesthesia and analgesia. 1983;62(2):174-80.
51. Gilron I, Orr E, Tu D, O'Neill JP, Zamora JE, Bell AC. A placebo-controlled randomized clinical trial of perioperative administration of gabapentin, rofecoxib and their combination for spontaneous and movement-evoked pain after abdominal hysterectomy. Pain. 2005;113(1-2):191-200.
52. Wu CL, Rowlingson AJ, Partin AW, Kalish MA, Courpas GE, Walsh PC, et al. Correlation of postoperative pain to quality of recovery in the immediate postoperative period. Regional anesthesia and pain medicine. 2005;30(6):516-22.
53. Popping DM, Zahn PK, Van Aken HK, Dasch B, Boche R, Pogatzki-Zahn EM. Effectiveness and safety of postoperative pain management: a survey of 18 925 consecutive patients between 1998 and 2006 (2nd revision): a database analysis of prospectively raised data. British journal of anaesthesia. 2008;101(6):832-40.
54. van Dijk JF, van Wijck AJ, Kappen TH, Peelen LM, Kalkman CJ, Schuurmans MJ. Postoperative pain assessment based on numeric ratings is not the same for patients and professionals: a cross-sectional study. International journal of nursing studies. 2012;49(1):65-71.
55. van Dijk JF, Kappen TH, Schuurmans MJ, van Wijck AJ. The Relation Between Patients' NRS Pain Scores and Their Desire for Additional Opioids after Surgery. Pain practice : the official journal of World Institute of Pain. 2015;15(7):604-9.
56. Maroney CL, Litke A, Fischberg D, Moore C, Morrison RS. Acceptability of severe pain among hospitalized adults. Journal of palliative medicine. 2004;7(3):443-50.
57. Sloman R, Wruble AW, Rosen G, Rom M. Determination of clinically meaningful levels of pain reduction in patients experiencing acute postoperative pain. Pain Manag Nurs. 2006;7(4):153-8.
58. Clark WC, Yang JC, Tsui SL, Ng KF, Bennett Clark S. Unidimensional pain rating scales: a multidimensional affect and pain survey (MAPS) analysis of what they really measure. Pain. 2002;98(3):241-7.
59. Argoff CE. Recent management advances in acute postoperative pain. Pain practice : the official journal of World Institute of Pain. 2014;14(5):477-87.
60. Mayo NE, Feldman L, Scott S, Zavorsky G, Kim do J, Charlebois P, et al. Impact of preoperative change in physical function on postoperative recovery: argument supporting prehabilitation for colorectal surgery. Surgery. 2011;150(3):505-14.
61. Ghaferi AA, Birkmeyer JD, Dimick JB. Complications, failure to rescue, and mortality with major inpatient surgery in medicare patients. Annals of surgery. 2009;250(6):1029-34.
62. Makary MA, Segev DL, Pronovost PJ, Syin D,

Bandeen-Roche K, Patel P, et al. Frailty as a predictor of surgical outcomes in older patients. Journal of the American College of Surgeons. 2010;210(6):901-8.
63. de Santibanes M, Alvarez FA, Sieling E, Vaccarezza H, de Santibanes E, Vaccaro CA. Postoperative complications at a university hospital: is there a difference between patients operated by supervised residents vs. trained surgeons? Langenbeck's archives of surgery / Deutsche Gesellschaft fur Chirurgie. 2015;400(1):77-82.
64. Haynes AB, Weiser TG, Berry WR, Lipsitz SR, Breizat AH, Dellinger EP, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. The New England journal of medicine. 2009;360(5):491-9.
65. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Annals of surgery. 2004;240(2):205-13.
66. de Vries EN, Ramrattan MA, Smorenburg SM, Gouma DJ, Boermeester MA. The incidence and nature of in-hospital adverse events: a systematic review. Quality & safety in health care. 2008;17(3):216-23.
67. Goslings JC, Gouma DJ. What is a surgical complication? World journal of surgery. 2008;32(6):952.
68. Neuss H, Reetz C, Raue W, Koplin G, Mall JW. Postoperative surgical complications after radical axillary lymph node dissection in melanoma disease result in increased pain. International surgery. 2010;95(2):166-71.
69. Deming WE. Out of the crisis. Cambridge: Massachusetts Institute of Technology Center for Advanced Engineering Study; 1986.
70. Erlenwein J, Koschwitz R, Pauli-Magnus D, Quintel M, Meissner W, Petzke F, et al. A follow-up on Acute Pain Services in Germany compared to international survey data. European journal of pain. 2016;20(6):874-83.

8

Summary
Samenvatting
Epilogue
Dankwoord/Words of gratitude
Curriculum Vitae
Publications
PhD portfolio

Summary

Postoperative pain is a common occurrence following surgery. Inadequate postoperative pain management is associated with several negative consequences, patient discomfort, and is linked to increased healthcare costs. The prevalence of moderate to severe postoperative pain in the Netherlands and in the rest of the world is high, varying between 41 % and 65 %.

In this thesis, our focus is on postoperative pain experienced by inpatients in an academic hospital setting in the Netherlands. The overall aim of this thesis was to explore the quality of postoperative pain management in hospitals. We used the Donabedian model to assess the quality of postoperative pain management, selecting a set of factors from each of the three categories: structure, process and outcome. In the category "structure", we investigated the presence and responsibilities of acute pain service (APS) teams in hospitals. Pain assessment was studied for the category "process". As "outcome", we explored pain assessment including pain scores, complications, and relationships between these two outcome variables.

This thesis is organized in three main parts based on the three factors of Donabedian's framework for modeling the quality of care. ***Chapter 1*** provides a general introduction.

Chapter 2, the first part of the thesis, describes a study on the organizational structure of postoperative pain management. We aimed to report on the current state, structure and responsibilities of the APS teams in Dutch hospitals and to review the implementation of the Dutch Hospital Patient Safety Program (DHPSP). Therefore, we conducted a digital questionnaire survey, sent to all 96 Dutch hospitals performing surgical procedures. Ninety percent of Dutch hospitals reported having an APS, which are predominantly nurse based and mostly supervised by an anesthesiologist. The majority of team members are nurses. APS teams differ in both the way they are locally organized, and in the activities they employ, divided into patient-related and non-patient-related activities. All APS members make daily rounds to evaluate surgical patients with complex pain treatments like epidural, loco-regional analgesia or patient controlled analgesia. All APS teams have educational tasks and some participate in quality improvement projects of pain management. Research by APS teams is not common. Furthermore, the hospital contact respondents indicated that almost all hospitals had pain protocols in place and that they assessed pain in surgical patients. They also reported that the DHPSP guidelines on pain assessment had been almost fully implemented. The majority of hospitals assessed pain at least three times a day, however 46 % offer no access to regular in hospital pain training and 13 % do not inform patients about pain after surgery. We concluded that for more effective APS, APS teams should invest in patient care as well as non-patient-related activities enhancing organizational

improvement of postoperative pain management.
In ***Chapter 3***, the second part of the thesis, we describe a study on the process of pain assessment in hospitals. The aim of this study was to examine the compliance with pain assessment in postoperative patients after implementation of the DHPSP, according to the national quality indicators for pain assessment in postoperative patients. Furthermore, organizational factors associated with this compliance were determined. We used two data sources: 1) data from an evaluation study of the Dutch Hospital Patient Safety Program; and 2) data from our study in Chapter 2. Data of 3,895 patient records from 16 hospitals showed a low compliance with pain assessment in postoperative patients. In 53 % of the postoperative patients, pain was assessed at least once a day on all three full days after surgery. In only 12 % of the postoperative patients was pain assessed at least three times a day, all three full days after surgery. Compliance was highest in general hospitals compared to tertiary teaching and academic hospitals, and was higher at the surgery and surgical oncology department compared to the other departments. We concluded that the implementation of pain assessment in hospitals is still insufficient, based on data from patient records.

In the third part of the thesis, we present three studies on the outcome of postoperative pain management in hospitals. In ***Chapter 4***, we examined if neuraxial or regional analgesia provide superior pain relief compared to patient controlled intravenous analgesia (PCIA) in three different procedures. We also identified the incidence of minor and major adverse effects or complications of these techniques. Prospectively collected data of postoperative patients from an online data registration system of a special dedicated nurse based APS were analyzed. The overall percentage of patients with moderate to severe pain on day 1-4 after surgery based on movement evoked numerical rating scale pain (NRS-MEP) scores were 50.3 % and 9.2 % respectively. We found that patients who received epidural analgesia and continuous peripheral nerve blocks reported lower pain scores than those who received PCIA, after undergoing the same procedures. Additionally, pain at rest scores were significantly lower than movement evoked pain scores. The incidence of severe nausea was mostly observed in patients with PCIA and itching was most common in patients with epidural analgesia. A major adverse effect, i.e. opioid induced respiratory depression was found in five patients with PCIA. Since pain scores may vary widely between patients with similar surgical procedures we recommended personalized pain measurement and pain management, in order to improve clinical practice.

In ***Chapter 5***, we described the relationships between pain scores and other methods of pain assessment, e.g. acceptability of pain or its interference with physical functioning. Therefore, we conducted a cross-sectional study on patients who underwent major surgery. 15,394 assessments in 9,082 patients in the first three postoperative days showed that the unidimensional NRS-MEP score does not entirely reflect the multidimensional aspects of postoperative pain. Low pain scores

do not guarantee that patients find their pain acceptable. Nor do high pain scores invariably mean that patients are not satisfied by their pain levels. Approximately one out of ten patients had unacceptable pain but reported a low NRS-MEP score of 0-4. Despite a high NRS-MEP score of 7, at least one in five patients were willing to accept their pain and, at the same time, performed the required physical activities. We concluded that pain management should be guided by the many dimensions of the patient's pain experience, not solely by cut-off points of a numerical pain score. We encouraged health professionals to use a multi-source pain evaluation by assessing a numerical pain score, the acceptability of the pain and physical functioning in order to balance pain treatment options and possible complications.

In ***Chapter 6***, we report on the relationship between postoperative pain and 30-day postoperative complications. Having postoperative pain was assessed in two ways: the movement-evoked pain score on the Numerical Rating Scale (NRS-MEP) and the patients' opinion whether the pain was acceptable or not. Outcome was the presence of a complication within 30 days after surgery. Additionally, outcome was the occurrence of one of three healthcare-associated infections (HAIs): lung infection, urinary tract infection, and surgical site infection. 39.2 % and 15.8 % of the patients reported moderate to severe pain respectively on day one after surgery; 37.0 % and 10.2 % on day two; and 32.1 % and 6.3 % on day 3. Overall, 16.8 % of the patients reported unacceptable pain on one of the first three postoperative days. We found that complications after surgery occurred more often in patients with postoperative pain. Especially, healthcare-associated infections were linked to pain on the first day after surgery. Expected pain and higher age directly predicted the occurrence of 30-day complications. Our data strongly supported the paradigm that insufficient pain control in the early postoperative phase leads to an increased risk of postoperative complications. Consequently, an early detection of pain to avoid complications after surgery is important.

In ***Chapter 7***, the main findings of the thesis are discussed. In addition, we presented recommendations to improve clinical practice, education and research. The results of our studies demonstrated that postoperative pain management can be improved by 1) optimizing APS teams, 2) performing frequent multidimensional pain assessments and by 3) evaluating outcome measures including postoperative complications. Using the Donabedian model, we have shown that the structure, the process, as well as the outcome of postoperative pain management are interrelated factors. In order to improve postoperative pain management, all the influencing factors need to be addressed. Therefore, a hospital-wide improvement program is necessary which reviews the role of APS teams and other professionals, and focuses on the improvement of adherence to multidimensional pain assessment and the evaluation of pain treatment according to the Plan-Do-Check-Act cycle (PDCA cycle). The program evaluation should include measures of the intensity of the pain, the patient's opinion on the acceptability of the pain, the observation of physical function, and the development of complications after surgery.

Samenvatting

Postoperatieve pijn is een veel voorkomende gebeurtenis na de operatie. Onvoldoende postoperatieve pijnbehandeling is geassocieerd met verschillende negatieve gevolgen, ongemak van de patiënt en is geassocieerd aan hogere kosten voor de gezondheidszorg. De prevalentie van matige tot ernstige postoperatieve pijn in Nederland en in de rest van de wereld is hoog, variërend tussen 41 % en 65 %.

In dit proefschrift ligt de focus op postoperatieve pijn die wordt ervaren door patiënten in een academisch ziekenhuis in Nederland. Het algemene doel van dit proefschrift was om de kwaliteit van postoperatieve pijnbehandeling in ziekenhuizen te onderzoeken. We hebben het model van Donabedian gebruikt om de kwaliteit van postoperatieve pijnbehandeling te beoordelen en een reeks factoren uit elk van de drie categorieën te selecteren: structuur, proces en uitkomst. In de categorie "structuur" hebben we de aanwezigheid en verantwoordelijkheden van acute pijn service (APS) teams in ziekenhuizen onderzocht. Pijnmeting werd bestudeerd voor de categorie "proces". Als 'uitkomst' hebben we pijnmeting waaronder pijnscores onderzocht, complicaties en de relaties tussen deze twee uitkomstvariabelen.

Dit proefschrift is georganiseerd in drie onderdelen, gebaseerd op de drie factoren van het model van Donabedian voor het beschrijven van de kwaliteit van de zorg. ***Hoofdstuk 1*** geeft een algemene inleiding. ***Hoofdstuk 2***, het eerste onderdeel van het proefschrift, beschrijft een studie over de organisatiestructuur van postoperatief pijnmanagement. We beoogden verslag te doen over de huidige status, structuur en verantwoordelijkheden van de APS-teams in Nederlandse ziekenhuizen en om de implementatie van het Nederlandse Veiligheidsmanagementsysteem (VMS) Veiligheidsprogramma te beoordelen. Daarom hebben we dwarsdoorsnede onderzoek gedaan via een digitale vragenlijst, uitgestuurd naar alle 96 Nederlandse ziekenhuizen die chirurgische procedures uitvoeren. Negentig procent van de Nederlandse ziekenhuizen meldde dat ze een APS hebben, die overwegend het "nurse based anesthesiologist supervised" model heeft. De meerderheid van de teamleden zijn verpleegkundigen. APS-teams verschillen zowel in de manier waarop ze lokaal georganiseerd zijn als in de activiteiten die zij verrichten, onderverdeeld in patiëntgerelateerde en niet-patiëntgerelateerde activiteiten. Alle APS-leden maken dagelijkse consultrondes om chirurgische patiënten te evalueren die complexe pijnbehandelingen zoals epidurale, loco-regionale of patiënt- gecontroleerde analgesie krijgen. Alle APS-teams hebben educatieve taken en sommige nemen deel aan kwaliteitsverbeteringsprojecten ten aanzien van pijnmeting of pijnbehandeling. Het uitvoeren van (wetenschappelijk) onderzoek door APS-teams is niet gebruikelijk. Bovendien hebben de aangeschreven contactpersonen van de ziekenhuizen aangegeven dat bijna alle ziekenhuizen pijnprotocollen hadden en dat zij gestructureerd pijn meten bij chirurgische patiënten. Zij hebben ook gemeld dat de richtlijnen van het VMS Veiligheidsprogramma ten aanzien van pijnmeting bijna

volledig zijn geïmplementeerd. De meerderheid van de ziekenhuizen zou drie keer per dag pijn meten bij patiënten, maar 46 % biedt geen toegang tot regelmatige bijscholing over pijn en 13 % informeert de patiënten niet over pijn na de operatie. We concluderen dat APS-teams voor effectievere APS zouden moeten investeren in zowel directe patiëntenzorg als in niet-patiëntgerelateerde activiteiten die de organisatie van postoperatief pijnmanagement kunnen verbeteren.

In ***hoofdstuk 3***, het tweede onderdeel van het proefschrift, beschrijven we een studie over het proces van pijnmeting in ziekenhuizen. Het doel van deze studie was te onderzoeken of de richtlijnen van het VMS Veiligheidsprogramma na diens implementatie wat betreft pijnmeting bij postoperatieve patiënten worden opgevolgd, volgens de nationale kwaliteitsindicatoren voor het meten van pijn bij postoperatieve patiënten. Bovendien werden organisatorische factoren die verband houden met deze opvolging bekeken. We hebben twee databronnen gebruikt: 1) gegevens uit een studie ter evaluatie van het VMS Veiligheidsprogramma; en 2) gegevens uit onze studie die in hoofdstuk 2 beschreven staat. Gegevens van 3.895 patiëntendossiers van 16 ziekenhuizen lieten een lage opvolging zien van de richtlijnen ten aanzien van pijnmeting bij postoperatieve patiënten. Bij 53 % van de postoperatieve patiënten werd pijn minstens één maal per dag gemeten op alle drie de dagen na de operatie. Bij slechts 12 % van de postoperatieve patiënten werd pijn ten minste drie keer per dag gemeten, alle drie de dagen na de operatie. De opvolging was het hoogst in algemene ziekenhuizen in vergelijking met academische ziekenhuizen, en was hoger bij de chirurgische en chirurgisch oncologische afdelingen in vergelijking met de andere afdelingen. Wij concludeerden dat de implementatie van pijnmeting in ziekenhuizen nog steeds onvoldoende is, gebaseerd op gegevens uit de patiëntdossiers.

In het derde onderdeel van het proefschrift presenteren we drie studies over het resultaat van postoperatief pijnmanagement in ziekenhuizen. In ***hoofdstuk 4*** presenteren we een studie waarin de vraag wordt gesteld of neuraxiale of regionale analgesie superieure pijnbehandeling biedt in vergelijking met patiënt gecontroleerde intraveneuze analgesie (PCIA) in drie verschillende chirurgische procedures. Ook identificeerden we de incidentie van ernstige en minder ernstige bijwerkingen of complicaties van deze technieken. Prospectief verzamelde gegevens van postoperatieve patiënten uit een online data registratiesysteem van een “special dedicated nurse based” APS werden geanalyseerd. Het algehele percentage patiënten met matige tot ernstige pijn op dag 1-4 na de operatie op basis van numerieke pijnscores bij bewegen (NRS-MEP) waren respectievelijk 50,3 % en 9,2 %. We stelden vast dat patiënten die epidurale of loco-regionale analgesie kregen, lagere pijnscores meldden dan patiënten die PCIA kregen, in groepen die dezelfde procedures ondergingen. Daarnaast waren pijn in rust scores significant lager dan de pijn bij bewegen scores. De incidentie van ernstige misselijkheid werd meestal waargenomen bij patiënten met PCIA , terwijl jeuk het meest voorkwam bij patiënten met epidurale analgesie. Een belangrijk negatief effect, een opioïd

geïnduceerde ademhalingsdepressie, werd gevonden bij vijf patiënten met PCIA. Aangezien de pijnscores erg varieerden tussen patiënten met soortgelijke chirurgische procedures, hebben we de aanbeveling gedaan dat bij het meten van pijn een meer gepersonaliseerde benadering moet worden aangehouden, alsook bij de behandeling van pijn.

In ***hoofdstuk 5*** beschrijven we de relaties tussen pijnscores en andere methoden van pijnbeoordeling, zoals het wel of niet acceptabel zijn van pijn voor patiënten en de impact die de pijn heeft op het fysiek functioneren. Daarom hebben we een dwarsdoorsnede onderzoek uitgevoerd aan de hand van standaard pijnmetingen die gedaan waren door de APS bij patiënten die een grote operatie hadden ondergaan. 15.394 standaard pijnmetingen bij 9.082 patiënten in de eerste drie dagen na de operatie toonden aan dat de unidimensionale pijnscore bij bewegen niet de multidimensionele aspecten van postoperatieve pijn weerspiegelt. Lage pijnscores garanderen niet dat patiënten hun pijn acceptabel vinden. Ook betekenen hoge pijnscores niet altijd dat patiënten ontevreden zijn met hun pijnniveau. Ongeveer één op de tien patiënten had onacceptabele pijn maar meldde een lage pijnscore bij bewegen van 0-4. Ondanks een hoge pijnscore bij bewegen van 7, was minstens één op de vijf patiënten bereid de pijn te accepteren en tegelijkertijd de vereiste fysieke activiteiten uit te voeren. Wij concludeerden dat pijnbehandeling moet worden geleid door de vele dimensies van de pijnervaring van de patiënt, en niet alleen door het overschrijden van een afkappunt van een numerieke pijnscore. We moedigden gezondheidswerkers aan om een multidimensionele pijnmeting te gebruiken voor het beoordelen van de pijnbeleving bij patiënten. Dit kan door minimaal een aantal zaken uit te vragen, zoals een numerieke pijnscore, het wel of niet acceptabel zijn van de pijn en het fysieke functioneren van de patiënt te observeren ter overweging van mogelijke pijnbehandelopties en eventuele complicaties.

In ***hoofdstuk 6*** rapporteren we over een studie naar de relatie tussen postoperatieve pijn en complicaties binnen 30 dagen na een operatie. Postoperatieve pijn werd op twee manieren gedefinieerd: de numerieke pijnscore bij bewegen (NRS-MEP) en de mening van de patiënt of de pijn acceptabel was of niet. De uitkomst was de aanwezigheid van een complicatie binnen 30 dagen na de operatie. Een andere uitkomst was de aanwezigheid van één van de drie gezondheidszorg-geassocieerde infecties (HAI's): longinfectie, urineweginfectie en wondinfectie. 39,2 % en 15,8 % van de patiënten meldden matige tot ernstige pijn op dag één na de operatie; 37,0 % en 10,2 % op dag twee; en 32,1 % en 6,3 % op dag 3. Over het algemeen meldde 16,8 % van de patiënten onacceptabele pijn op één van de eerste drie dagen na de operatie. Het ontstaan van complicaties na een operatie kwam vaker voor bij patiënten met postoperatieve pijn. Vooral ook de gezondheidszorg-geassocieerde infecties waren geassocieerd met pijn op de eerste dag na de operatie. Verwachte pijn en hogere leeftijd voorspelden direct het optreden van complicaties binnen 30 dagen na de operatie. Onze gegevens ondersteunen het paradigma

dat onvoldoende pijnbehandeling in de vroege postoperatieve fase leidt tot een verhoogd risico op postoperatieve complicaties. Bijgevolg is een vroege detectie van pijn om complicaties na de operatie te vermijden belangrijk.

In ***hoofdstuk 7*** worden de belangrijkste bevindingen van het proefschrift besproken. Daarnaast hebben we aanbevelingen gedaan om de klinische praktijk, het onderwijs en het onderzoek te verbeteren. De resultaten van onze studies hebben aangetoond dat postoperatieve pijnbehandeling kan worden verbeterd door 1) het optimaliseren van APS-teams, 2) het uitvoeren van regelmatige multidimensionele pijnbeoordelingen en 3) de evaluatie van uitkomsten van pijnbehandeling, inclusief postoperatieve complicaties. Met behulp van het Donabedian model hebben we aangetoond dat de structuur, het proces, evenals de uitkomst van postoperatief pijnmanagement factoren zijn die onderling met elkaar verbonden zijn. Om postoperatief pijnmanagement te verbeteren, moeten alle beïnvloedende factoren worden aangepakt. Daarom is een ziekenhuisbreed verbeterprogramma nodig dat de rol van APS-teams en andere gezondheidswerkers evalueert en zich richt op de verbetering van de naleving van multidimensionele pijnmetingen en de evaluatie van pijnbehandeling volgens de Plan-Do-Check-Act-cyclus (PDCA cyclus). De evaluatie van het verbeterprogramma moet in ieder geval de meting van de intensiteit van de pijn bevatten, alsook het oordeel van de patiënt over het wel of niet acceptabel zijn van de pijn, de observatie van het fysiek functioneren en de ontwikkeling van complicaties na de operatie.

Epilogue

Now I have finished my thesis. I am very grateful that I was given the opportunity to immerse myself in postoperative pain management. Some of the questions I had before starting my research have been answered. However some of them have not been answered. During my research, more questions arose on certain topics, resulting in perspectives for future research.

Pain is a personal, subjective experience that arises in the conscious brain, typically associated with actual or potential tissue damage, or described in terms of such damage. As it is a subjective emotional sensation, reliable tools are required to facilitate the diagnosis and treatment of pain in clinical practice. Evaluation of whether pain therapy is effective should account for patients' experience and sensation.

My goal is to prevent patients from unnecessary suffering caused by postoperative pain. I believe that postoperative pain management can be improved by optimizing APS teams, optimizing frequent pain assessments, and by analyzing patient outcomes. But we need to work together with our patients in achieving this goal. We need to empower them and embrace shared decision-making. Because our patients are the ones actually feeling the pain. Without their cooperation and consent, pain management can never be optimal. In my work as the hospital-wide process supervisor patient empowerment is my first priority.

I will continue advocating the importance of adequate assessment and treatment of postoperative pain, in the clinic in individual patients as well as during education and training sessions for health care professionals. Additionally, I will continue advocating the analysis of pain data and facilitate quality improvement projects. Finally I will continue my research on postoperative pain management, with the help of our patients.

I have finished my thesis, but I have not yet finished my work. I believe that somewhere in the future postoperative pain will be managed adequately in all patients.

Rianne van Boekel

Dankwoord / Words of gratitude

Mijn proefschrift is klaar! Ik heb met veel plezier gewerkt aan de onderzoeken beschreven in dit proefschrift. Achteraf lijkt de tijd gevlogen, maar ik weet dat sommige onderdelen veel tijd hebben gekost. Ik heb in deze periode, en ook voordat ik startte met mijn promotie onderzoek, met veel mensen gewerkt die me hebben geïnspireerd en geholpen de juiste keuzes te maken en me verder op weg te helpen. Omdat het onmogelijk is om iedereen bij naam te noemen zonder iemand te vergeten, wil ik iedereen die op enige wijze heeft bijgedragen aan de totstandkoming van mijn proefschrift hartelijk danken. Een aantal mensen zal ik hieronder extra noemen.

Mijn dank gaat allereerst uit naar de patiënten en overige respondenten wiens gegevens ik mocht gebruiken voor de onderzoeken in dit proefschrift. Ik weet dat het niet altijd gemakkelijk is om vragenlijsten in te vullen en onderzoekers te woord te staan. Zonder uw medewerking waren mijn onderzoeken niet van de grond gekomen.

Buitengewoon veel dank gaat uit naar mijn promotor en co-promotoren, Prof. dr. K.C.P Vissers, dr. M.A.H. Steegers en dr. R. van der Sande.
Beste Kris, jij bent als geen ander in staat om het beste uit mensen te halen en hen te “lanceren”. Je hebt mij vanaf het begin gestimuleerd, geholpen en uitgedaagd. Samen hebben we verschillende brainstorm momenten gehad en gesprekken (o.a. tijdens lange autoritten!) gevoerd om visie te bepalen en beleidsvoorstellen te bedenken. Je hebt het altijd over de belangrijke combinatie van een gelijk gestemde arts en verpleegkundige die samen op trekken. Ik hoop dat wij deze visie nog lang mogen uitdragen.
Lieve Monique, vanaf het begin ben jij mijn begeleidster en sparringpartner geweest. Zowel als begeleidster tijdens mijn master Epidemiologie als mijn co-promotor stond jij bijna elke week voor mij klaar. Motiverend en kritisch, twee uitstekende eigenschappen die mij hebben geholpen te komen waar ik nu sta. We zijn nu samen de Nederlandse netwerkleiders van het mooie EFIC PAIN OUT project waarmee we hopelijk weer een stap zetten in de kwaliteitsverbetering van postoperatieve pijnbehandeling!
Beste Rob, jij was diegene die mij op het goede spoor zette toen ik twijfelde over welke opleiding handig was om onderzoeksvaardigheden op te doen. Je had al heel snel door dat ik onderzoeks-minded was. Samen hebben we het leeuwendeel van de NWO-aanvraag geschreven. En groot was de blijdschap toen na vele rondes bekend werd dat de promotiebeurs voor leraren werd toegekend! Dankzij deze beurs werd ik twee dagen per week vrijgespeeld om onderzoek te doen. Als niet pijn-deskundige was jouw nuchtere inbreng en kennis van onderzoeksmethoden in het geheel van groot belang.

Lieve Jos (Lerou), via Monique werd mij de kans gegund om samen met jou intensief verder te werken aan verschillende artikelen. Ik heb ontzettend genoten van jouw enthousiasme, kennis en tijdsinvestering. Uren hebben we doorgebracht met “de benen op tafel” om de koers te bepalen, berekeningen te doen, literatuur te bespreken en interessante wetenschappelijke discussies te voeren. Jouw bezielende begeleiding heeft mijn resultaten absoluut naar een hoger plan getild!

Prof.dr. van der Hoeven, prof.dr. Vermeulen en prof.dr. Rawal wil ik hartelijk danken voor hun bereidheid zitting te nemen in de kleine commissie; het manuscript door te lezen en te beoordelen.
Dear Narinder, your passion for the benefits of the nurse-based anesthesiologist-supervised acute pain service has been an inspiration in my work starting at my visit in Örebro in 2007. I thank you and Renee for your kind invitation, excellent information and help. It is an honour to have you in my commission.
Ook de overige commissieleden wil ik hartelijk danken voor hun aanwezigheid bij mijn promotie.

Mijn paranimfen, Jürgen Eikholt en Jessica Fifis ben ik tevens zeer dankbaar. Jürgen, als broer van Marcel sta jij vanzelfsprekend altijd overal dichtbij, maar jouw ideeën, uitstekende horeca ervaring en organisatietalent waren voor mij een geruststelling in dit laatste spannende moment van promoveren. Jessica, jij bent één van mijn beste vrienden sinds we elkaar tegenkwamen op de eerste dag van de introductie van de HBOV in 1992. Wij raken nooit uitgepraat en vullen elkaar geweldig aan. Ik vind het fantastisch dat je naast me staat op deze dag om me, zoals je altijd doet, te vullen met kracht en energie.

Ik dank alle collega’s van Radboudumc, die mij sinds mijn officiële aanstelling in 1993 hebben gevoed met kennis en vaardigheden en hebben geholpen om mijn pad te vervolgen tot waar ik nu sta. De collega’s en oudcollega’s van het Pijnteam en de Acute Pijn Service (APS) in het bijzonder. Ik heb veel van jullie geleerd en vind het nog steeds fijn om met jullie samen te werken. De collega’s van de APS hebben bovendien geholpen bij de gegevensverzameling van een aantal onderzoeken in dit proefschrift. Een aantal wil ik graag nog extra noemen. Paul en Agnes, toen ik in november 2002 op mijn eerste dag toch een tikje onzeker binnenkwam, hebben jullie ervoor gezorgd dat ik mij vanaf de eerste minuut welkom voelde. Verder stimuleerden jullie me om mijn ideeën op papier te zetten en uit te voeren. Beste Paul, jij hebt me als verpleegkundig hoofd destijds, samen met Robert, altijd alle ruimte gegeven om mijn eigen plan te trekken. Ik heb ook altijd erg genoten van jouw verhalen over de tijd dat jij als leerling-verpleegkundige werkte. Lieve Suzanne, jij bent samen met mij naar Örebro in Zweden gegaan om de werkwijze van de APS daar te gaan observeren en deze zo goed mogelijk over te nemen in onze nieuw te vormen nurse-based acute pain service. Je bent altijd een collega geweest waar ik op kon bouwen en ik vond het zo fantastisch dat jij en Paul de reis naar Amsterdam ondernomen hebben om aanwezig te zijn bij de diploma-uitreiking van mijn master

Epidemiologie!
Lieve Petra, jij was de eerste collega die we konden aannemen in de nieuwe APS. Jij hebt er mede voor gezorgd met jouw gedegen aanpak en nauwkeurige werk dat de APS een succesverhaal werd en blijft. Petra, Floor, Jutta, Suzanne, Monique en Inge, dit doen jullie nog steeds samen met mij elke dag!
Inge, als oudpromovenda en inmiddels gepromoveerd weet jij als geen ander wat voor werk een promotie met zich meebrengt. Dank voor jouw begrip en motivatie!
Marijke, als hoofdverpleegkundige heb je altijd je best gedaan om mij met al mijn taken en verantwoordelijkheden op zoveel verschillende plekken, de ruimte te geven die ik nodig had om optimaal te functioneren. Dit waardeer ik enorm en daar ben ik je erg dankbaar voor!
Robert, eerst als collega, toen als hoofd, daarna weer als (parttime)-collega heb ik altijd jouw steun en vertrouwen gevoeld. We hebben zelfs gebrainstormd over een ambitieus projectidee in CWZ waar ik ook op zou kunnen promoveren. Helaas was de tijd daarvoor in CWZ nog niet rijp. Veel dank!
Kees, jouw heerlijk nuchtere humor heeft mij altijd geholpen de zaken in perspectief te zien, ook in de periode dat ik het zwaar had tijdens de ziekte en het overlijden van mijn vriendin. Met jouw palliatieve kennis gaf je raad en advies, maar ook acceptatie. En qua promoveren: “gewoon dóen” is jouw credo, en dat heb ik opgevolgd. Verder heb je me ook nog behoed voor een grote fout op het titelblad. Leuk zo'n vrijdag ;-)).
Lieven, wat weet jij verschrikkelijk veel en wat ben je altijd ontzettend bereid om te helpen, hoeveel tijd het ook kost. Ik vergeet nooit meer dat we ooit samen een avond hebben doorgehaald om de onderzoeksgegevens netjes in EPIC te krijgen. Het was zo laat dat je uiteindelijk bij ons thuis een geïmproviseerd bed opzocht om toch nog wat nachtrust te krijgen. Ik hoop dat we nog veel samen op mogen trekken!
Beste anesthesiologen, hoewel misschien vaak onbewust hebben jullie ook een grote rol gespeeld in mijn promotie traject. Door gesprekken over patiëntengroepen, type OK’s, pijnscores, rapporten, EPIC, protocollen, richtlijnen etc. hebben jullie me geïnspireerd en gevoed om verder onderzoek te doen. Ik hoop dat dit nog lang zo mag doorgaan!

Beste mensen van het secretariaat, jullie wil ik hartelijk danken voor jullie hulp op allerlei manieren tijdens mijn promotie traject. Léon, Laura, Marieke, Bianca, Bert, Xandra, Nicole, Rina, Ando, Elvira, Diana, maar eerder ook Anneke en Monique, ik kon altijd een beroep op jullie doen voor afspraken in overvolle agenda’s, printerproblemen, vergaderruimtes, bestellingen die niet waren geleverd, voorraadbeheer, computerprogramma’s die vastliepen of die niet deden wat ik wilde. Dank daarvoor!
Ook de mensen van het bedrijfsbureau Mariska, Berti, Carlot, Daniëlle en eerder ook Joleen wil ik graag danken voor jullie steun. Joleen, jij hebt het mogelijk gemaakt dat de APS database, APPG-Web, een database werd waar we iets mee konden! Berti, jij bent onmisbaar geweest met jouw kennis over onder andere

computersystemen en databases en jouw praktische inslag. Ik hoop dat we hier nog lang samen in op mogen trekken.

Beste onderzoekers en andere bewoners van de vierde verdieping, Yvonne, Jeroen, Marieke, Marlieke, Jelle, Patrick, Ria, Hans, Tijn, Marianne, Loes, Ceciel, Agnes, Anne, Inge en Jackie, wat heerlijk dat ik bij jullie een echte onderzoeksplek heb. Hans, wat kunnen wij heerlijk brainstormen samen over onderzoeksideeën en statistische bewerkingen. En handig zo'n white board dan! Lowlands, Groot Nationaal Onderzoek, het kan allemaal. Ook het tot op de letter nakijken van mijn manuscript deed je gewoon erbij, ontzettend fijn! Ik hoop voor jou dat jouw proefschrift ook snel klaar is. Met jouw onderzoekskennis en -ervaring ben je een enorme steun voor me geweest tijdens mijn promotie traject en als het aan mij ligt werken we nog lang samen.
Yvonne, ook jij hebt mij vanaf het begin gestimuleerd om het onderzoek in te gaan. Ik kan altijd bij jou terecht met vragen; je maakt altijd tijd. Gezellig is het ook altijd, met of zonder cocktails! Dank je wel voor jouw steun en coaching.
Beste Jasper, dank voor de vormgeving van mijn boekje, leuk dat je nu een eigen bedrijf hierin hebt!
Tijn, hartelijk dank voor jouw meedenken in allerlei trajecten, raad en advies. Je helpt me altijd weer verder.

Beste verpleegkundigen van de preoperatieve poli, hartelijk dank voor jullie hulp bij het recruteren van patiënten voor mijn predictie onderzoek! Hanneke, dank voor jouw motivatie en stimulatie hierin!

Ook prof. dr. Scheffer en drs. Broecheler, als afdelingsleiding, wil ik hartelijk danken dat zij het mogelijk hebben gemaakt dat ik mijn promotie-onderzoek op de afdeling Anesthesiologie Pijn en Palliatieve Geneeskunde heb kunnen doen. Ik ben nog steeds ontzettend blij met mijn onderzoeksplek op de vierde verdieping. Beste Gert Jan en Simon, ik vind het ontzettend knap dat jullie ondanks de steeds krapper wordende budgetten veel moeite doen om de menselijke maat te blijven hanteren en mensen de ruimte te geven om te ontwikkelen. Dank daarvoor!

Ik dank alle collega's van de Hogeschool van Arnhem en Nijmegen die mij sinds mijn officiële aanstelling in 2011 hebben gecoached en bijgestaan om mijn didactische vaardigheden verder te ontwikkelen. De collega's en oudcollega's van HAN VDO in het bijzonder. Ik heb veel van jullie geleerd en vind het nog steeds fijn om met jullie samen te werken. Een aantal wil ik graag extra noemen, Sylvia Hoekstra, Irma Mosselman, Marion Giesberts, Jos Vermeulen, Reinhard Schulte, Wendy Kermper-Koebrugge, Wietse Meulendijks, Gideon Visser en Fernand van Westerhoven.
Beste Sylvia, jij herkende mijn passie voor het vak van verpleegkundig pijnconsulent en zag meteen de mogelijkheden om binnen de HAN een 2- jarige opleiding pijnconsulent te gaan ontwikkelen. Jouw kennis van het opzetten van een opleiding

en coaching van mij als beginnend opleider hebben mede het voortdurende succes van de opleiding bepaald! Lieve Irma, jouw rust, kalmte en relativeringsvermogen hebben mij vaak geholpen om gebeurtenissen, zoals bepaalde vormen van studentengedrag, in perspectief te zien en weer verder te kunnen. Lieve Marion, wat was ik blij dat jij liet doorschemeren dat je best weer in Nijmegen zou willen werken. We kennen elkaar al heel lang en ik had sterk behoefte aan een sparringpartner binnen de opleiding. Maar je bent veel meer dan dat. Je bent mijn steun en toeverlaat en je hebt me vanaf het begin in mijn twijfel over een promotie traject tot nu toe altijd gemotiveerd, gecoached en ondersteund. Ik kan volledig op jou bouwen, veel aan je overlaten en samen hebben we al veel voor elkaar gekregen. Ik hoop dat we nog lang mogen samenwerken!
Jos, zo'n ervaren doorgewinterde opleider als jij bent altijd een inspiratie, maar qua ondersteuning bij mijn promotie traject is het vooral jouw humor en relativeringsvermogen waar ik veel aan heb gehad. Dank! Beste Reinhard, de manier waarop jij in het leven staat en de wijze van doorzetten en positieve energie, daar neem ik een voorbeeld aan. Dank! Wendy, Wietse en Gideon, jullie zijn mijn onderzoekscollega's. Ik hoop dat we met zijn allen een mooi programma gaan neerzetten volgens ons plan. Dank voor jullie meedenken en wetenschappelijke discussies!
Beste Fernand, ook jou ben ik extra dank verschuldigd voor jouw voortdurende steun en erkenning. Alle ruimte krijg ik om de zaken zo te organiseren zoals ik denk dat goed is. Ik weet inmiddels dat dit voor mij ook het beste werkt en de beste resultaten oplevert. Ik hoop dat we nog lang mogen samenwerken en dat we daar komen waar onze ambities liggen!

Beste Cecile Nijsten, hartelijk dank voor het houden van de vinger aan de pols tijdens mijn promotie traject. Tevens dank voor de fijne gesprekken die we gevoerd hebben over promoveren, NWO en de periode na promotie.

Beste collega's van de lectoraten van GGM van de HAN, hartelijk dank voor de kennis en inspiratie die ik bij jullie heb opgedaan. In het bijzonder het Lectoraat Eerstelijnszorg met dr. van der Sande, Lectoraat Innovatie in de care met dr. Adriaansen en dr. Verschuur en Lectoraat Acute Intensieve Zorg met dr. Vloet en dr. Berben, waar ik het meeste mee te maken heb gehad. Beste Rob, Marian, Els, Lilian en Sivera, ik hoop dat we het onderzoek in de lectoraten in de toekomst verder kunnen uitbouwen.

Beste collega's van het secretariaat en bedrijfsbureau, jullie hebben mij zo veel mogelijk ondersteund en werk uit handen genomen, zodat ik in mijn drukke agenda ook tijd vond voor mijn onderzoek. Beste Thea Duijs, Fadoua Fighil, Stella Vlaswinkel, Marlies Beekmans, Marsja van Leest, Angela Radochyna, Tamara van der Linden, Monique Uijen en Betty van Engelen, hartelijk dank!

Aan alle co-auteurs, bedankt voor de samenwerking en jullie bijdrage aan de

manuscripten.

Beste studenten die hebben meegewerkt aan het onderzoek Pijnpredict; jullie namen staan allemaal genoemd in mijn PhD portfolio. Hartelijk dank voor jullie tijd en inzet ter ondersteuning van mijn studie!

Naast mijn werk in het Radboudumc en de HAN, vind ik het leuk om ook breder met het vak bezig te zijn. Bedankt collega's en medebestuursleden van V&VN Pijnverpleegkundigen, NVAM, DPS en P.A.I.N.

Naast het werk vind ik afleiding in volleybal. Bedankt IKAROS recreantenteam voor de afleiding, gezelligheid en natuurlijk het volleybal!

Al mijn lieve vrienden, dank jullie voor jullie geduld en begrip, ook in tijden waarin we minder intensief samen konden zijn. Goede vriendschap blijft bestaan!
Lieve ouders en schoonouders, fijn dat jullie er altijd zijn. Jullie stonden en staan altijd voor mij klaar. Lieve papa en mama, ik ben blij met jullie als ouders en wil jullie bedanken voor alles wat jullie voor mij hebben gedaan.

En dan mijn eigen gezin, Marcel, Lucas, Emma en Sophie. Marcel, jij bent de liefde van mijn leven en ik zou me geen leven zonder jou kunnen voorstellen. Samen kunnen wij alles aan. Ik ben je ontzettend dankbaar voor jouw steun tijdens dit promotie traject, zonder jou was het niet gelukt. Ik hou van je.
Lieve Lucas, Emma, Sophie, mama was soms wel erg druk, toch? Dank jullie wel voor jullie lieve hulp. Mama houdt heel veel van jullie! "Love you, love you too, very much, bye bye!"

Curriculum Vitae

Rianne van Boekel was born in Oss and grew up in Schaijk, a small village on the countryside of The Netherlands. After primary school, she went to secondary school, the gymnasium in Oss, a city just 10 kilometres away. Six years later she passed for gymnasium. She continued with Nursing on the higher professional educational level, being a student nurse in the Radboud university medical center when she was 19 years old. At the age of 23, she received her Bachelor of Nursing. Her job was offered immediately after her graduation in the department of General Internal Medicine and then at the Thorax / Heart Surgery department. After three years, she started nursing education specializing in intensive care nursing. After four years at the Intensive Care department, she accepted the position of clinical pain nursing consultant at the Department of Anesthesiology, Pain and Palliative Medicine. She is still working at this department and has since been employed as a nursing expert and is the hospital leader for the theme "Early Recognition and Treatment of Pain". In this function, she is responsible for all aspects of pain in patients, such as protocols, work instructions, patient education, training programs, reports and quality improvement programs of individual departments.

In addition to clinical work, Rianne initiated the two-year post-graduate program for pain nursing consultant at the HAN University of Applied Sciences in 2011. She still coordinates this training and some other courses related to pain and palliative care at the HAN. Furthermore, she has accepted the assignment to promote research and evidence based practice and give these topics a more prominent place in the courses within HAN VDO. In 2013 she won a personal scholarship, "NWO Promotion Grant for Teachers", to start her PhD study on acute postoperative pain management in collaboration with the Radboud University Medical Center and HAN.

In 2014, Rianne successfully completed the Master Epidemiology at the EMGO Institute for Health and Care Research (EMGO +), the Interfaculty Research Institute of the VU Medical Center and the VU University in Amsterdam. She is an active member of the research department of Anesthesiology, Pain and Palliative Medicine of Radboud University Medical Center, and participated in various research projects, aiming to bring research closer to the public society, such as the Radboud research team at Lowlands 2016 and the Great National Research on the Sensitivity of Pain in The Netherlands.

Supporting the development of pain nursing consultants, Rianne became the president of the Dutch Association of Pain nurses in 2015, an association that she founded with other colleagues in 2006. In this association, she has taken care of, among other things, the establishment of the area of expertise

of Pain Nursing, as well as the Pain Nursing domain in the Nurses' Quality Register. She is also the president of the multidisciplinary Working Group that prepares the new quality indicator Hospital-wide Pain Management for the Healthcare Inspectorate's Basic set of Quality Indicators of hospitals. She also served as a board member of the Dutch Pain Society and has been in Pain Alliance in the Netherlands (P.A.I.N.), established since April 2017.

Rianne is married to Marcel Eikholt. Together they have three children, Lucas, Emma and Sophie, respectively, 14, 12 and 9 years old.

Publications

- **van Boekel RLM**, Nielen RGC, Vissers KCP, van de Sande R, Lerou JGC, Steegers MAH. Relationship between postoperative pain and adverse events in a broad surgical population. Submitted in Annals of Surgery.

- **van Boekel RL**, Vissers KC, van der Sande R, Bronkhorst E, Lerou JG, Steegers MA. Moving beyond pain scores: Multidimensional pain assessment is essential for adequate pain management after surgery. PloS one. 2017;12(5):e0177345.

- Hoogervorst-Schilp J, **van Boekel RL**, de Blok C, Steegers MA, Spreeuwenberg P, Wagner C. Postoperative pain assessment in hospitalised patients: National survey and secondary data analysis. International Journal of Nursing Studies. 2016;63:124-131.

- **van Boekel RL**, Vissers KC, van de Vossenberg G, de Baat-Ananta M, van der Sande R, Scheffer GJ, Steegers MA. Comparison of Epidural or Regional Analgesia and Patient-controlled Analgesia: A Critical Analysis of Patient Data by the Acute Pain Service in a University Hospital. Clinical Journal of Pain. 2016; 32: 681-688

- **van Boekel R**. Pijn bij kanker: verpleegkundige zorg in alle facetten. Kankerbreed.2015;7(2): 13-16.

- **van Boekel RL**, Steegers MA, de Blok C, Schilp J. [Pain registration: for the benefit of the inspectorate or the patient?]. Nederlands Tijdschrift voor Geneeskunde. 2014;158:A7723

- Houweling PL, Molag ML, **van Boekel RLM**, Verbrugge SJC, van Haelst IMM, Hollmann MW.['Postoperative pain treatment' practice guideline revised]. Nederlands Tijdschrift voor Geneeskunde. 2013;157: A7005.

- **van Boekel RL**, Steegers MA, Verbeek-van Noord I, van der Sande R, Vissers KC. Acute Pain Services and Postsurgical Pain Management in the Netherlands: A Survey. Pain Practice. 2015; 15(5):447–454.

- **Boekel RLM**, Steegers MAH, van der Sande R, Vissers KCP. Postoperative pain assessment should not be solely based on numeric ratings! Commentary on Van Dijk et al. (2011). International Journal of Nursing Studies. 2012;49(5):631–633.

- **van Boekel R**. Werkgroep onderwijs is klaar voor de toekomst! Pijnperiodiek. 2012;2(6):20-21.

- **van Boekel R**. Hoogwaardige pijnzorg van verantwoord niveau. Pijnperiodiek. 2012;3(6):12-15.

- **Boekel R van**, Steegers M, Vissers K. Week van de pijn in Radboudumc: bewustwording en borging. Nederlandstalig Tijdschrift Pijnbestrijding. 2012;31(51):3-9.

- **Boekel R van**. Implementatie. TvZ Tijdschrift voor verpleegkundigen. 2010;120(7):65-68.

- **Boekel R van**. Voor een optimale postoperatieve pijnbehandeling: De Acute Pijn Service. TvZ Tijdschrift voor verpleegkundigen. 2010;120(6):30-33.

- **Boekel R van**. Postoperatieve pijnbehandeling. TvZ Tijdschrift voor verpleegkundigen. 2010;120(6):40-45.

- **Boekel R van**, Giesberts MG, Roode E de; Snel herstellen na uw operatie? Blijf de pijn de baas!; NTVA; jaargang 26, nr 3, mei 2009.

- **Boekel R van**, Complicaties van postoperatieve pijnbehandeling; NTVA; 2006.

- **Boekel R van**, Giesberts MG; Pijnbehandeling kan effectiever en veiliger; Verpleegkunde Nieuws 03;2005:27-29.

- Giesberts M, **Boekel R van**; Minder pijn voor de patiënt: de rol van de pijnverpleegkundige; Kwaliteit in Beeld 2004;6:8-9.

- Vroom M, **Boekel R van**, Giesberts M; Postoperatieve pijnbehandeling kan nog beter; TVZ nr 9, september 2004.

PhD Portfolio

Name PhD student:	RLM van Boekel RN MSc
Period:	2013-2017
Radboudumc Department:	Anesthesiology Pain and Palliative Medicine
Promotor:	Prof. dr. KCP Vissers
Co-promotors:	dr. MAH Steegers, dr. R van der Sande
Research School:	Radboud Institute for Health Sciences

1. PhD training

General academic skills

Introductie Nijmeegse curricula (startkwalificatie onderwijs)	2017	(0.2 ECTS)
Mediatraining	2017	(0.2 ECTS)
Scientific Integrity for RIHS and RIMLS PhD students	2015	(0.4 ECTS)
Academic Writing	2015	(3.0 ECTS)

Research skills

NWO Inspiratiedag promotiebeurs voor leraren	2017	(0.3 ECTS)
Basiscursus regelgeving en organisatie voor klinisch onderzoekers (BROK)	2016	(1.0 ECTS)
Summercourse HAN University of Applied Sciences	2016	(0.3 ECTS)
Summercourse HAN University of Applied Sciences	2015	(0.3 ECTS)
Radboud Institute for Health Sciences Introduction Course for PhD students	2014	(0.6 ECTS)
Longitudinale data-analyse	2014	(3.0 ECTS)
Master epidemiologie (EMGO/VU)	2014	(60.0 ECTS)

Oral Presentations

Societal Impact of Pain (SIP) congress Malta	2017	(1.0 ECTS)
7e nationaal pijn Congres V&VN Pijnverpleegkundigen	2016	(0.3 ECTS)
Avondsymposium Pijn bij kanker: meten en begeleiden	2016	(0.1 ECTS)
Avondsymposium Pijn bij dementie	2015	(0.1 ECTS)
Refereeravond “Pijn in al zijn facetten” Ziekenhuis Rivierenland Tiel	2015	(0.1 ECTS)
Minisymposium “Pijn en palliatieve zorg; zorg ondersteund door netwerken”	2015	(0.1 ECTS)
Radboud Research Rounds	2015	(0.1 ECTS)
Nederlandse OK dagen	2014	(0.2 ECTS)
Invitational conference Acute Pain Service	2013	(0.1 ECTS)
XXIX Annual ESRA congress	2010	(1.0 ECTS)

Poster Presentations

World Institute of Pain (WIP) 8th World congress	2016	(1.0 ECTS)
European Federation of IASP Chapters (EFIC) 9th Congress	2015	(1.0 ECTS)
World Institute of Pain (WIP) 7th World congress	2014	(1.0 ECTS)
Congres NVA/VAP/V&VN Pijnverpleegkundigen "Pijndagen"	2012	(0.2 ECTS)
IASP 14th World Congress on Pain	2012	(1.0 ECTS)

Seminars and workshops

Nederlandse OK-dagen	2015	(0.2 ECTS)
6e nationaal congres V&VN Pijnverpleegkundigen	2014	(0.3 ECTS)
Admiraal de Ruyter ziekenhuis Goes/Vlissingen	2014	(0.2 ECTS)
Studiedag Palliatieve zorg; voor en door elkaar. (3x)	2014	(0.3 ECTS)
Verpleegkundige Adviesraad. Passie voor pijn	2013	(0.1 ECTS)
Lectoraat acute intensieve zorg	2013	(0.1 ECTS)
Congres NVA/VAP/V&VN Pijnverpleegkundigen	2012	(0.2 ECTS)
5e nationaal congres V&VN Pijnverpleegkundigen	2012	(0.3 ECTS)
Venticare	2010	(0.2 ECTS)
4e nationaal congres LVP	2010	(0.2 ECTS)
Expeditie Patientveiligheid (VMS programma)	2010	(0.2 ECTS)

International conferences

Societal Impact of Pain (SIP) congress Malta	2017	(1.0 ECTS)
World Institute of Pain (WIP) 8th World congress	2016	(1.0 ECTS)
European Federation of IASP Chapters (EFIC) 9th Congress	2015	(1.0 ECTS)
World Institute of Pain (WIP) 7th World congress	2014	(1.0 ECTS)
IASP 14th World Congress on Pain	2012	(1.0 ECTS)
XXIX Annual ESRA congress	2010	(1.0 ECTS)

2. Teaching activities

Lecturing

Cursus Postoperatieve Pijn Radboud Health Academy	2017	(0.5 ECTS)
Keuzeblok 5KVZ5 Geneeskunde	2016-2017	(0.1 ECTS)
Incompany cursus Acute pijn service medewerker ZRT	2015	(0.5 ECTS)
St Martins' home White-Yellow Cross Foundation	2015	(2.0 ECTS)
Minor Pijn multidisciplinair HAN	2014-2017	(0.4 ECTS)
ZZG Zorggroep	2012	(0.4 ECTS)
Minor Oncologie HBOV HAN	2011-2013	(0.3 ECTS)
Opleiding Pijnconsulent HAN VDO	2011-2017	(200 ECTS)
Cursus Assistent Pijnbehandeling HAN VDO	2010-2017	(60 ECTS)
Keuzeblok KNW7 Geneeskunde	2010-2017	(0.5 ECTS)
Specialistische verpleegkundige vervolgopleiding Snijdende Specialismen Radboud Health Academy	2010-2017	(1.2 ECTS)

Specialistische verpleegkundige vervolgopleiding Maag Darm Lever-verpleegkunde	2010-2017 (1.2 ECTS)
Specialistische verpleegkundige vervolgopleiding Longverpleegkunde	2010-2011 (0.3 ECTS)

Supervising students on research projects

Verpleegkunde (HBOV):	
Mandy Wiggers en Nina Vermaas (APS UMCN)	2010
Marianne Hollestelle en Marianne Hogendoorn (APS UMCN)	2011
Karin van der Heijden en Lieve van Dalen (verpleegkundige interventies acute postoperatieve pijn)	2011
Yvonne de Bruin en Jet Brinks (verpleegkundige interventies preventie chronische pijn)	2011
Carmen Garraud en Rosan van der Wijst (APS)	2011
Sylvia Luijten en Anouk van Betteraij (zorgpad chronische pijnpatiënt)	2012
Aniek Verheggen en Maruschka Seegers (APS)	2012
Juul Altinga en Cecile Buurman: (Pijnpredict: preoperatieve pijn)	2013
Luuk Aarts en Karin Matser (Pijnpredict: geslacht)	2013
Tom Bik en Anne-Marit Kort (Pijnpredict: chronische pijn)	2013
Lonneke Kuipers en Merit Struik (Pijnpredict: catastroferen)	2015
Kim van Woezik en Noor Nusselder (Pijnpredict: PSQ)	2013
Frank Vermeer en Sandra Maas (Pijnpredict: angst)	2015
Bas Altstadt en Niek Vlekken (Pijnpredict: postoperatieve complicaties)	2015
Danique Mulder en Judith Raaijmakers (Pijnpredict: preoperatieve pijn)	2015
Kim Hermans en Tamara Verstraten (palliatie onderwijs NPZZG)	2015
Vanity Looyschelder (Pijnpredict: preoperatieve pijn)	2016
Mariëlle Heusinkveld en Sanne Verheijen (Pijnpredict: postoperatieve complicaties)	2016
Maureen Tittse, Nicole Roelofs en Bas van Uden (Pijnpredict: postoperatieve complicaties)	2017
Deli Ahoud en Seyenna Vink (Pijnpredict: Janssen indeling)	2017
Alyssa Misseyer en Anne Aarts (Pijnpredict: postoperatieve complicaties)	2017

Bachelor medische hulpverlening (BMH):	
Kimberley Geven en Michelle Peperkamp (Pijnpredict: regel)	2012
Mirjam Schakenbos en Sanne Schakenbos (Pijnpredict: angst)	2014
Terry van Grunsven en Lisa van Bergen (Pijnpredict: leeftijd)	2014
Cynthia Bosman en Jeroen Takke (Pijnpredict: angst)	2014
Jesse Liebrand en Rossy Scharbaay (Pijnpredict: complicaties)	2014
Anne van Lamoen, Carlijn Smits, Willem Vincken (Pijnpredict: complicaties)	2015
Geneeskunde:	
BOWO blok:	
Nicole van Vlijmen en Karin ter Weele	2012-2013
Jedda Eppink en Maarten te Groen, Jelmer van Dijk en Lizzy Harmsen	2013-2014
Alexander Janssen en Joris Drossaers, Lara van der Schoot en Hielke Markerink	2014-2015
Mathijs Weijers en Hugo Aarts, Robin Ros en Stef Schoenmakers	2015-2016
Eerstejaars Geneeskunde met innovatieproject:	
Matthijs, Thomas, Lars en Casper Tacke (PONV)	2016
Tweedejaars Geneeskunde met onderzoeksproject:	
Maaike Kampshoff en Marly Habets (preoperatieve chronische pijn)	2016
Biomedische wetenschappen (BMW):	
Frederique Vermeulen (Janssen categorieën)	2015
Renske Nielen (postoperatieve complicaties)	2015
Roderick van Oudenaerde (postoperatieve outcome)	2015
Daan van den Nieuwenhof, Leah Jacobs en Bart Sloot (postoperatieve complicaties)	2016
Master Advanced Nursing Practice (MANP)	
Ingeborg de Booij-Liewes-Thelosen (thuisbloeddrukmeting)	2015
Jantine Boerrigter- van Ginkel (preoperatieve informatie)	2015

3. Awards

X2 Ambition Award The best leadership in combining patient care, education and research, and having a societal impact	2017
TOPP stuk-award The best scientific output in 2013	2014
NWO Grant: Netherlands Organization for Scientific Research PhD Grant for teachers Five year financial support for PhD research	2013