A modern pain neuroscience approach in patients undergoing surgery for lumbar radiculopathy: a clinical perspective
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Abstract

Around 20% of patients undergoing surgery for lumbar radiculopathy develop chronic pain after surgery, leading to high socioeconomic burden. Current perioperative interventions, including education and rehabilitation, are not always effective in preventing prolonged or chronic postoperative pain and disability. Here, a shift in educational intervention from a biomedical towards a biopsychosocial approach for people scheduled for lumbar surgery is proposed. Pain neuroscience education (PNE) is a biopsychosocial approach that aims to decrease the threat value of pain by reconceptualizing pain and increasing the patient’s knowledge about pain. This paper provides a clinical perspective for the provision of perioperative PNE, specifically developed for patients undergoing surgery for lumbar radiculopathy. Besides the general goals of PNE, perioperative PNE aims to prepare the patient for postsurgical pain and how to cope with it.
Introduction

Prevalence of chronic low back pain is estimated at 19.6% in persons aged between 20 and 59 years\textsuperscript{1,2}. A specific subgroup of patients with chronic low back pain are patients with low back and radiating leg pain, that is, lumbar radiculopathy. According to the National Institute for Health and Care Excellence (NICE) guidelines, lumbar radiculopathy is described as unilateral leg pain worse than back pain with pain radiating to the foot or toes, numbness and paresthesia in the same distribution and associated with motor neurological deficit\textsuperscript{3}. Surgical decompression of the symptomatic lumbar nerve root is considered a cost-effective treatment for radiculopathy, in particular when conservative treatments fail and symptoms persist\textsuperscript{4-6}. Success rates of surgical interventions for lumbar radiculopathy are estimated around 75% to 80\%\textsuperscript{5,7}.

Despite this rather high surgical success rate, 23% to 28% of patients undergoing decompression surgery end up with chronic back or leg pain\textsuperscript{5,8-10}. These unfavorable surgical outcomes are associated with higher levels of postoperative health care utilization, incurring more health care costs\textsuperscript{11} and leading to high socioeconomic burden. The development of postsurgical chronic pain can be due to a multitude of factors, including but not limited to negative psychological factors, preexisting chronic pain, psychological disorders, high sensitive C-reactive protein, or preoperative axial joint pain\textsuperscript{8,12,13}.

After surgery, there is a wide variety of postoperative rehabilitation interventions differing in content and mode of delivery (duration and intensity)\textsuperscript{14}. Rehabilitation programs comprising exercises started 4 to 6 weeks postsurgery seem to be superior to no treatment for decreased pain and disability, whereby high-intensity exercise programs lead to a faster decrease in pain compared with low-intensity programs\textsuperscript{14}. A systematic review by Snowdon et al (2016) showed that physical therapy started in the first 4 weeks postsurgery is safe and effective for pain reduction\textsuperscript{15}.

Perioperative rehabilitation is often supplemented with some form of education as a possible strategy to lower the risk for complications and long-term disability\textsuperscript{16}. A survey among 89 spine surgeons revealed that most provide some form of education to their patients before they undergo lumbar radiculopathy surgery. However, the educational content mainly covers biomedical and anatomical topics such as spine anatomy and a technical explanation of the surgical procedure using a spine model, listing possible complications, and discussing outcomes following surgery\textsuperscript{17}. Until now, educational interventions also provided by other health care providers (e.g., physical therapists) were often biomechanically focused, including information about anatomy and biomechanics of the spine, detailed anatomical explanation of the surgical procedure, and ergonomic advice\textsuperscript{18}. Furthermore, the information available online is mostly focused on tissue pathology with limited integration of pain physiology and psychosocial influences\textsuperscript{19}. In the case of an acute problem, patients can benefit from information regarding the anatomy of the region. However, such an anatomically driven educational approach seems to be less valuable and insufficient when patients are experiencing persistent pain\textsuperscript{20,21}. Moreover, providing such information can increase anxiety and stress in patients undergoing surgery for lumbar radiculopathy\textsuperscript{22,23}, which in turn relates to negative outcomes in terms of increased postoperative pain\textsuperscript{24-28}. Additionally, patients are not always satisfied with the information provided about their impending surgery\textsuperscript{29}. Apart from information about the surgical procedure and associated risks, they also want to gain knowledge about their pain and the impact of the surgery\textsuperscript{30}.

As the goal of perioperative education is to optimally prepare patients for their surgery and further postoperative rehabilitation trajectory, a more biopsychosocial approach is suggested. This includes providing patients information regarding the expected postoperative pain and the influence of cognitive-behavioral factors on their rehabilitation following surgery for lumbar radiculopathy\textsuperscript{31}. The idea of teaching patients what pain exactly is, based on a biopsychosocial framework, was first successfully used by Louis Gifford in the 1990s in his clinical practice\textsuperscript{32}. During the following years, the
evidence for biopsychosocial approaches, and more specifically, for the addition of pain neuroscience education (PNE) to rehabilitation programs\textsuperscript{33-41}, kept evolving, leading to the current general awareness about the importance of biopsychosocial frameworks\textsuperscript{42,43}. Despite increased awareness, the effective implementation in clinical practice of such a biopsychosocial approach remains challenging and is currently still limited to multidisciplinary teams and pain clinics. This indicates the need for instructions about how to apply biopsychosocial interventions in particular populations in clinical practice.

PNE is a cognitive-based intervention to inform patients about what to expect from the evolution of their pain, de-emphasize the pathoanatomical content, and focus on the factors that contribute to the development of pain, all within a biopsychosocial framework, meaning that PNE is changing the beliefs of patients\textsuperscript{44-46}. Within a surgical population, education should not only address the underlying mechanisms of perioperative pain, but it should also aim to reassure the patient about the decision to have surgery.

Face-to-face sessions of PNE supplemented by written educational material are effective in pain reduction, increasing function, changing pain beliefs, and reducing health care expenditure in patients with various chronic pain disorders (Figure 1)\textsuperscript{31,34,35,39-41,47-50}. PNE not only aims to educate patients, it also includes counseling and empowerment to facilitate effective pain coping\textsuperscript{51}. By understanding pain better, its threat value will decrease, which will lead to more effective pain coping strategies\textsuperscript{52-54} and improved functioning of brain-orchestrated nociceptive inhibition (i.e., the capacity of the brain to activate powerful top-down nociceptive inhibition)\textsuperscript{34}. Dysfunctionality of the latter is one of the cardinal features of postoperative pain\textsuperscript{55-58}. This mechanism partly explains why patients continue to experience pain after tissue healing. Preoperative measures of endogenous nociceptive inhibition appear to have predictive value for the development of chronic pain postsurgery\textsuperscript{59-61}. As mentioned before, PNE was found to activate brain-orchestrated endogenous nociceptive inhibition in patients with chronic pain\textsuperscript{34}.

\textbf{Figure 1:} Effects of pain neuroscience education in patients with chronic pain\textsuperscript{23,34,35,39-41,47-49,51,62}

A recent multi-center randomized controlled trial in patients undergoing surgery for lumbar radiculopathy demonstrated that one preoperative PNE session supplemented by reading material resulted in significantly lower levels of health care use and costs up to 3 years postsurgery compared
with patients receiving only usual care\textsuperscript{63}. One year postoperatively, health care expenditure in patients who received preoperative PNE was 45% lower compared with those receiving usual care only. These expenses remained 37% lower at 3 years postsurgery despite similar levels of low back pain, leg pain, and disability\textsuperscript{23,63}. These results suggest a behavioral change in those patients who received preoperative PNE even though their pain and disability did not show a significantly different evolution compared with patients receiving only usual care\textsuperscript{23,63}. Therefore, the reason for the change in health care-seeking behavior should be sought on a different level. Presumably, the positive effect of PNE on pain-related cognitions, which has been demonstrated in a wide variety of populations\textsuperscript{33,35} including chronic low back pain\textsuperscript{41,48,64} and surgical patients\textsuperscript{65,66}, plays an important role in this mechanism. This relationship between pain cognitions and health care utilization has been suggested in several populations, with maladaptive cognitions and beliefs leading to disproportionately high levels of health care use\textsuperscript{67-75}. Subgroups of patients undergoing surgery for lumbar radiculopathy show maladaptive pain cognitions such as pain catastrophizing\textsuperscript{76,77} and kinesiophobia\textsuperscript{76,78-80} in the perioperative period. Apart from the possible link between maladaptive pain cognitions and high levels of health care utilization in this population, maladaptive pain cognitions are also associated with worse surgical outcome\textsuperscript{66}. These facts emphasize the relevance for providing perioperative PNE to patients undergoing surgery for lumbar radiculopathy from the perspective of both the patient and society.

So far, only preoperative PNE has been investigated in patients undergoing surgery for lumbar radiculopathy. However, we deem perioperative PNE to be even more appropriate in this population, as patients experience a typical change in pain severity, and often location, from the pre- to postoperative phase, characterized by the new onset of (inflammatory) surgery-elicited pain\textsuperscript{62}. This highlights the need for a second session in the early postoperative period. Additionally, to obtain effective coping strategies in patients, there should be a transfer from knowledge about pain to an adaptive behavioral change, which can be facilitated by adding an extra session to the PNE intervention\textsuperscript{62}.

Providing PNE to patients scheduled for surgery for lumbar radiculopathy poses a dramatic shift towards a biopsychosocial approach of perioperative care instead of the biomedical approach still commonly used in practice. Here, we propose a clinical perspective for the application of perioperative PNE in patients undergoing surgery for lumbar radiculopathy based on the current best evidence and the authors’ own clinical experience.

**PNE in Patients Undergoing Surgery for Lumbar Radiculopathy: Application in Clinical Practice**

**Target population**

Pain is one of the most common symptoms following surgery, making PNE especially useful in the postsurgical population. In contrast to the application of PNE as a treatment for chronic pain, perioperative PNE can also be applied for primary prevention of maladaptive coping with postsurgical pain and eventually the development of chronic pain.

Above all, PNE can be applied in populations already presenting chronic pain preoperatively and in patients at high risk for development of chronic pain postoperatively, such as patients undergoing lumbar surgery\textsuperscript{13}. In these patients, PNE can be useful to prepare them for postoperative suffering and facilitate the development of appropriate pain-related cognitions and coping strategies.
Treatment protocol

The proposed treatment protocol includes 2 individually tailored sessions of PNE (each taking about 1 hour), one before and one after the surgery, complemented by an informative booklet. Optionally, the booklet can be supplemented by an online interactive part. The content of the education should be adapted to the individual profile of the patient, including the pathology and scheduled type of surgery. An overview of the topics that should be addressed in the pre- and postoperative PNE session are shown in Figure 2. The content of perioperative PNE is based on the books of van Wilgen and Nijs\textsuperscript{81} as well as Butler and Moseley\textsuperscript{52}; studies by Nijs et al (2011, 2014)\textsuperscript{42,51}, Louw et al (2011, 2013)\textsuperscript{44,82}, and McGregor et al (2007)\textsuperscript{83}; and our own clinical experience.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Content of the pre- and postoperative pain neuroscience education sessions}
\end{figure}

PNE is usually provided by physical therapists\textsuperscript{23,64,84} and is presented as such in this clinical perspective. However, other medical care staff (e.g., surgeons and nurses) can also provide this type of education if they receive extensive training in techniques for effectively transferring information to patients and training about the concept and content of PNE, which is similar to the training physical therapists should receive\textsuperscript{85}.

The aim of preoperative PNE is to help patients with the reconceptualization of their pain by defocusing the attention on the nociceptive input from the affected areas and enhancing the focus on pain as an increase in nerve sensitivity and upregulation of the peripheral and central nervous system\textsuperscript{44}. In addition to the standard PNE content, patients undergoing surgery will receive information on how to prepare for the surgery and what to expect afterwards. The key concept is to reduce anxiety and uncertainty and to attain positive expectations and beliefs regarding the scheduled surgery\textsuperscript{86}.

Specific topics that should be addressed preoperatively are (1) the decision to have surgery, (2) the goal of the surgery, and (3) recovery after surgery\textsuperscript{83,87}.

Postoperative PNE should focus on the patient’s illness perceptions and implementation of the knowledge about pain mechanisms in daily living. Postoperative PNE should be highly individually tailored and focus on pain-coping strategies by helping patients with the transfer of knowledge about pain to an adaptive behavioral change\textsuperscript{62}. Furthermore, this postoperative PNE session gives patients the opportunity to ask additional questions, as uncertainties about postoperative experiences and/or
sensations and possible (un)fulfilled expectations often arise after surgery. In this way, the therapist will be able to reassure the patient.

Preoperative PNE: face-to-face session

In line with the current best evidence about the timing of preoperative education, it is recommended to organize the first session during the week before surgery. Hospitalization and surgery can provoke high levels of stress and anxiety in patients, with the highest levels the day before surgery, possibly blocking effective learning. Therefore, we suggest not providing the education the day before surgery. On the other hand, 14 days before surgery seems to be too early for providing preoperative education, with no beneficial effects on postoperative recovery, fear, and anxiety. From a practical viewpoint, this might imply that the first session has to be organized at home, as an additional hospital visit before the surgery hospitalization is often not feasible for the patient.

The presented preoperative session takes approximately 60 minutes. To succeed in the goals of PNE, it is of utmost importance to create a therapeutic alliance with your patient. Therefore, the therapist should primarily gain insight in the previous steps taken by the patient before the surgery was planned, as this will contain valuable information about the patient’s coping strategies and how he/she handled previous unpredicted events. All this information can be used to individualize the content of the therapy. Effective, continued learning is easier when the patient is motivated and the information is personalized, which emphasizes the role of a good alliance between therapist and patient.

In terms of content, the preoperative face-to-face educational session should preferably contain 4 parts: (1) education about the physiology of the pain system, (2) a discussion of the final decision of the patient to have surgery, (3) an explanation of the goal of the surgery, and (4) a discussion of postoperative recovery.

First, the physiology of the pain system is explained, including adaptations in case of sensitization. This part of the education is similar to providing PNE to patients with nonsurgical chronic pain, which is already well established in the literature. Therefore, only the key components of this part of the PNE intervention will be described. These should be explained to the patient in layman’s terms and preferably by using examples relevant to the individual patient. Furthermore, one should bear in mind that, at this stage the patient might not be experiencing pain yet.

The therapist should start with explaining acute pain and normal functioning of the pain system: the full signal transmission from the peripheral cell to the dorsal horn in the dorsal column, up to the brain, including top-down nociceptive inhibition, facilitation, and signal processing in the brain. Additionally, specific attention should be given to the concept of radicular pain in these patients. Due to specific processes such as mechanical compression caused by a lumbar disc herniation, osteophytes, narrowing of the spaces within the spine (i.e., peripheral foraminal stenosis), etc., a specific nerve root will be compressed, resulting in pain following the dermatomes of that nerve root. It should be explained to patients that the cause of their pain is located in the back and not in the lower limb, clearly pointing out the importance of back surgery, especially when patients are not experiencing back pain. After surgery, most patients will experience some form of (adaptive) central nervous system sensitization, wherefore the adaptations occurring in case of sensitization should be explained as well. This includes providing information regarding receptor field growth, potentiation of the postsynaptic membrane, and changes at the cortical and subcortical levels.

Second, the final decision to have surgery should be discussed. Most patients have tried several conservative therapy options (e.g., physiotherapy, medication, infiltrations) before they were finally faced with the option of surgery. Often, individuals are still struggling with contradictory feelings about
previously failed treatments and stories of negative outcome by peers who underwent surgery (Figure 3).

**Therapist:** How do you feel about your surgery tomorrow?

**Patient:** I’m really anxious about the procedure. I had no other option than undergoing surgery, as all other treatments I tried were unsuccessful. So, I hope the surgery will finally lead to a solution.

**Therapist:** It is perfectly normal that you are anxious and you did what everyone would do, trying to avoid surgery. This is a whole new experience. Keep in mind that the goal of the surgery is to eliminate the cause of your symptoms in your back and leg. Moreover, the surgeons are well-trained to perform this surgery and it has good success rates.

**Patient:** I hope the surgeon is able to solve my problem. I already visited a physiotherapist and I underwent 3 infiltrations last month. Every time I thought that those interventions would be the solution. However, this was not the case.

**Therapist:** I understand, but that was way before you learned about the physiology of nervous system. You now know that sometimes physiotherapy and infiltrations are not sufficient to eliminate the structural cause of your symptoms.

**Patient:** I know, but it is difficult. My sister also had this surgery and that didn’t turn out well.

**Therapist:** Many people, indeed, know relatives who underwent back surgery. However, you’ve now learned that no two people are the same. This is because pain is multidimensional, meaning that multiple factors besides structural damage will determine if one will experience pain. This implies that focusing on other people’s outcome, will not teach you more about your situation.

**Patient:** You are right, I see, this is my body and my decision, so worrying about someone else’s result does not make any sense. I shall try to focus on my recovery instead of worrying about the procedure.

**Figure 3:** Conversation between patient and therapist regarding the final decision to undergo surgery

Continued rumination about decisions can create stress, fear, and maladaptive pain cognitions, which in turn will keep stimulating the sensitized state of the nervous system. Patients who accept their need for surgery have a better outcome than patients who continue doubting their decision.\(^{83,84}\). This highlights how important it is to discuss this topic and acknowledge the possible fears patients may be experiencing and also to convince and reassure them that undergoing surgery was the right decision.

Third, the goal of the surgery should be addressed. Patients often receive only a brief explanation about the surgery during their consultation with the surgeon. This can overwhelm them with new
information, and several questions can arise. To reduce stress levels, the educational session is an ideal opportunity to rephrase the most important goal of the surgical procedure. Nevertheless, it should not be a technical description of the surgical procedure or a detailed explanation on the anatomical structures, and care should be taken that the words and pictures used to explain this are nonthreatening to the patient. The goal is to focus on the broad concepts of the intervention in order to reduce stress and uncertainties preceding surgery.

Most importantly, the emphasis should be on the fact that the surgical procedure is executed to resolve the problem the patient is experiencing at this moment, that is, back and/or leg pain, and that he/she should rely on the effectiveness of the procedure. More specifically, it should be explained that the main goal of the surgery is to remove the irritation from the nerve that is bothering the patient at this moment and that the surgeon will do their utmost to obtain this goal. Subsequently, it can be explained that when the irritation is resolved, the nerve will again have sufficient space, ability to move, and blood supply to enable tissue healing and desensitization of the nerve. However, also make clear that tissue healing takes time and that it is perfectly normal to experience some pain after a successful surgery.

Last, the recovery after surgery should be discussed. Pain is an expected and normal symptom following a surgical procedure. This can partly be explained by postoperative inflammation. It is important to inform patients in advance that they can still experience pain after surgery. This is a normal process due to the oversensitive state of the nervous system, which needs time to calm down. Furthermore, at this stage, there is still some time needed to enable tissue healing, which should eventually lead to pain cessation. Understanding the concepts of acute pain and the adaptations in case of sensitization, as well as the role of worrying in these mechanisms, is crucial to calm down the nervous system. The basic idea should be that pain is a product of our brain rather than a reflection of (the degree of) tissue damage. When patients do not fully understand these mechanisms and the underlying reason why they experience pain following surgery, they are prone to start worrying, which could lead to negative emotions and maladaptive coping mechanisms. The latter in turn can lead to the development of chronic pain. In that case, the tissues will heal, but the nervous system will not get the opportunity to calm down and the patient will continue to experience pain. This emphasizes the importance of providing basic knowledge about pain mechanisms in this preoperative session.

It can be recommended to use pain medicine in an early stage after surgery to start being physically active, within the limits imposed by the surgeon and related to the particular surgical intervention. Physical activity will activate endogenous hypoalgesia, which will help calm the nervous system. The latter, in combination with tissue healing, will eventually lead to the possibility of decreasing painkiller intake.

To close the preoperative educational session, it can be useful to provide a questionnaire for the patient to be completed before the postoperative PNE session. This questionnaire should examine the patient’s knowledge about pain mechanisms as well as attributions and cognitions towards pain. We propose to use a combination of multiple-choice and open questions; as the former are easy to complete, but the latter might provide the therapist with more useful information. An example of such a questionnaire can be found in the eAppendix. Based on the answers, the therapist will be able to first address shortcomings in the patient’s knowledge and subsequently rectify any possible maladaptive pain cognitions and attributions.

An alternative option for the questionnaire can be The Revised Neurophysiology of Pain Questionnaire, which can be used as a standard tool in patients undergoing surgery for lumbar radiculopathy. However, it will only give the therapist an idea about which parts of the neurophysiology of pain (first part of the face-to-face session) were not well understood by the patient and will not provide information on the other parts of the education.

Besides the use of a self-reported tool, the therapist can also ask patients to explain the pain they are currently experiencing in their own words. This can be done in role playing with the therapist acting as
an old friend of the patient who is ignorant of pain science and asks naïve questions about the patient’s pain.97-99.

*Postoperative PNE: face-to-face session*

A postoperative PNE session is important because patients typically experience changes in pain severity from the pre- to the postoperative phase, including the onset of (inflammatory) surgery-elicited pain. Furthermore, this postoperative session creates the ideal occasion to facilitate the transition from the obtained knowledge about pain to an adaptive behavioral change (Figure 4). To obtain the latter, illness perceptions should be addressed, underscoring the fact that this session should be highly individually tailored.42.
Therapist: During our previous session we discussed how certain activities and behaviors can have an influence on pain symptoms. Do you remember the substances in your body that could decrease the alarm signal going from your spinal cord to your brain?

Patient: Yes, I think they were called endorphins?

Therapist: Correct! And can you give me an example of a situation when these substances will be activated in your body?

Patient: When you are performing sports. I experienced that once myself. When I bruised my ankle during jogging, it did not hurt that much. But afterwards, the pain started kicking in.

Therapist: Indeed, good example. There are several other situations where these substances are released, for example in situations of great joy and happiness. Negative emotions on the other hand, can enhance the signal that is transmitted to the brain. Do you also have an example of such a situation?

Patient: I have the impression that when I focus on the pain in my leg, it is more present compared to when I’m doing an activity I enjoy and do not think about my pain.

Therapist: Yes, the signal can be enhanced by worrying, which will maintain the hypersensitivity of your central nervous system. Can you think of a practical example in your daily life?

Patient: I realize that I should try to worry as less as possible about my pain. I will have to search for activities, that I am allowed to perform after my surgery, that divert my attention from the pain. Although, it will not be easy as my surgeon told me I have to rest enough, and mostly it is while resting that the worrying starts.

Therapist: I understand that. Nevertheless, it is important to seek for activities you can do while you are physically resting, for example reading a book or filling out a word puzzle. Also other things, like enjoying the attention from your family can be beneficial. And from the moment you are allowed to perform any physical activity, try to do so. Even short walks can be enough to calm down your nervous system.

Patient: Alright, that is interesting. I will certainly try to be active within the necessary limits. And, indeed, my recovery might be the ideal occasion to make some time for my family.

Figure 4: Conversation between patient and therapist regarding the application of knowledge about pain mechanisms on daily life

We advise to provide this session between 1 day postoperatively and discharge from the (acute) hospital. This will ensure that patients are optimally prepared to return to a situation where the medical support will be less extensive.

During the postoperative session, the following subjects should be addressed: (1) the postoperative timeline, (2) repetition of the knowledge about pain mechanisms, and (3) biopsychosocial postoperative pain management.
First, the therapist should gain insight into the patient’s pain and present feelings, as these will influence the session’s content. Despite the information provided during the preoperative PNE session, many patients are still confused after surgery. This often relates to the lack of pain reduction, complications, and the limited amount of movements they are allowed to perform. Feeling confused can keep the nervous system sensitized. Therefore, it is important to listen to and ease patients by reminding them about the content of the first session concerning pain mechanisms, sensitization, and the reasons why they might still experience pain immediately following surgery.

It is important to reassure the patient that, if the surgery was anatomically successful, the anatomical cause of their symptoms is solved and that at this stage tissue healing is still ongoing. The latter implies that the nervous system is still sensitized. Patients should be convinced that after the period needed for tissue healing, the pain should disappear. However, they should be aware that maladaptive thoughts and cognitions may increase pain perception. This stresses the importance of focusing on the psychosocial part following surgery rather than on the biomedical aspect of the symptoms to facilitate the process of calming the nervous system. Furthermore, patients should be reassured that symptom fluctuations are normal in the former process.

Second, it is recommended to provide a short repetition of the explanation of acute pain mechanisms and central nervous system sensitization during the postoperative PNE session. This can be accomplished by using a summarizing picture, presenting the whole pathway from stimulus to the production of pain by the brain. An example of such a picture is presented in Figure 5. If the knowledge of the patient on this matter was tested using a questionnaire in between sessions, the particular shortcomings in the patient’s knowledge can subsequently be discussed in more detail.

**Figure 5:** Example of an image presenting the complete pathway from stimulus to the production of pain by the brain.

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Last, postoperative pain management should be discussed. There are 3 aspects that can be exerted to control postoperative pain: knowledge, movement, and medication (Figure 6). It should be clear that PNE is no replacement for other parts of the medical management of patients undergoing surgery for lumbar radiculopathy. With its main objective of educating patients about the pain system, including the influence of psychosocial factors, how to cope with surgical outcomes, as well as reassuring the patient about their decision to have surgery, it should serve as a parallel track in the rehabilitation trajectory next to other components such as pharmacological management and exercise therapy. Providing patients with adequate knowledge on pain mechanisms and insight into the negative influence of, for example, catastrophizing and stress on the sensitized state of the nervous system gives them an accurate view of the “pain concept.” Patients who understand this concept well may be able to calm their nervous system. However, because this is a rather complicated concept, it is recommended to advise patients to reread their informative booklet once they return home. In this way, they may get answers on uncertainties about their current symptoms.

![Figure 6: Controlling postoperative pain: a 3-factor model](image)

Physical activity can also be used for pain control as far as moving is allowed following the surgical intervention. Physical activity can induce the release of nociception-inhibiting substances, which emphasizes the need to physically activate patients as soon as possible. However, in patients experiencing high levels of pain, this nociception-inhibiting system is likely failing with decreasing pain thresholds as a result. Therefore, the first days after surgery, patients can be instructed to take medication to calm the sensitive state of the nervous system and help the brain re-fulfil normal functions. As mentioned before, this will also make it possible to start moving without excessive pain. Nevertheless, one should keep in mind that together with tissue healing, it will be the goal to gradually diminish the amount of oral painkillers.

When postsurgical activity restrictions apply, the therapist should discuss movements with the patient that they are allowed to perform safely, so that inactivity is restricted to the essential minimum. In this context, the therapist should always consider the fact that some patients are too motivated. It has to be clear that, although physical activity within the imposed limits is beneficial for the patient, intensive sport activities in the early postsurgical state are to be avoided.
Patients are often overwhelmed by all the information on the surgical procedure, possible risks, and the recovery process, leading to low percentages of information retention\textsuperscript{40}. Additionally, patients who experience pain sometimes report attention deficits and difficulties with concentration\textsuperscript{62}. To maximize information retention, the use of an informational booklet is strongly recommended\textsuperscript{44}. It can be used as an adjunct to the verbally provided PNE information\textsuperscript{44}. Written information is known to improve compliance, reduce anxiety, and promote general well-being\textsuperscript{83}. To make patients feel more comfortable and confident, patients should be advised to read the booklet before their surgery. Furthermore, they should be encouraged to read the booklet in the first postoperative days and weeks, as it can help to reduce rumination and consequent fear or anxiety, serve as a reminder, and optimize effective, continued learning\textsuperscript{62}.

As the content of the booklet should be in line with the information provided by the physical therapist, it is recommended to create a booklet containing information specific for this particular condition and scheduled surgery of the patient.

**Supplementary online interactive module**

In this digital era, an online interactive module can increase the attractiveness of the therapy, particularly for people who do not like to read. In an online module, the information addressed in the educational booklet can be provided by videos or interactive presentations. Another benefit of this approach is that the patient can be asked certain questions while completing the module to test their knowledge. When a question is answered incorrectly, the patient can be advised to repeat that particular part of the module. Furthermore, this form of blended learning has been found to be an effective approach for delivering PNE\textsuperscript{37}.

An example of an interactive online module can be found online at www.retrainpain.org. The Retrain Pain module focuses on patients with chronic pain and should therefore be adapted for patients undergoing surgery for lumbar radiculopathy. However, the general concepts are very suitable for all patients confronted with pain. The website explains why pain is a useful and protective mechanism. Another module discusses nerve hypersensitivity, and another module uses the metaphor of pain as a fire alarm to emphasize the need of another approach to treat the hypersensitive nervous system. Separate modules expand on the role of the brain, descending inhibition, and descending facilitation. Additionally, the influence of the context on pain and information about what causes pain is provided. Although specific topics regarding the surgical procedure and expectations after surgery are not provided, this general background could be very beneficial for patients undergoing surgery for lumbar radiculopathy.

**Practical considerations**

**Individual vs group sessions**

PNE is usually provided by a physical therapist in a one-on-one format. This approach is preferred over group sessions because of its larger effect sizes\textsuperscript{40}, individually tailored interaction, and lower threshold to ask questions to the therapist. On the other hand, group sessions can be beneficial to promote mutual patient contact and diminish the feeling of being the only person who experiences such suffering from pain. Furthermore, one might assume that group sessions are less costly, but this should be balanced against the smaller effect sizes for pain decrease and disability\textsuperscript{40}. It can also be hard to
schedule group sessions within the optimal time frame around the surgery, especially in smaller hospitals where these surgeries are performed at a lower frequency, as the timing of the PNE sessions depends on the surgical schedule of the hospital.

Additionally, the suggested (individualized) PNE program is designed in a concise manner, comprising only 2 one-on-one education sessions, each lasting about 1 hour. Yet it is a complete program, including measures to guarantee effective, continued learning such as the informational booklet and online module. Therapists also have a flexibility of 1 week to organize the first individual session. Despite these characteristics of the program, in some health care systems and particular clinical settings, resources and time may be limited, making it impossible to organize individual sessions. In that case, one might consider implementing the presented PNE content in group sessions and therefore profit from the advantages of group therapy.

Transdisciplinary approach

Some patients are not convinced by the biopsychosocial principles of this type of education, as they stick with the biomechanical explanation for their symptoms. Such patients often show underlying psychological resistance obstructing the acceptance of an oversensitive nervous system. It is a challenge for the physical therapist to identify these barriers, preventing patients from changing their beliefs. However, at a certain point, the physical therapist should accept the fact that a particular patient might not be suitable for PNE. Continuing to impose the content of the education on a patient is also not beneficial. To counter this problem, it can be recommended for future research to conduct studies providing PNE in a transdisciplinary manner. These treatment programs could involve both physical therapists and psychologists, who can provide patients with insights from their own backgrounds. Physical therapists have extensive knowledge concerning the anatomy of the body, functional recovery after surgery, and the influence of cognitions on these biomedical factors. On the other hand, psychologists might be more familiar with handling persistent maladaptive cognitive factors and encouraging a behavioral change in such complicated situations. We assume that receiving the same message from health care providers with different backgrounds will be more helpful compared with receiving the information from only one individual therapist. This can be very useful because patients undergoing surgery for lumbar radiculopathy often have an extensive history of biomedically focused contacts in health care, with different health care providers, increasing their chance of developing maladaptive pain cognitions.

During the pre- and postsurgical phases, patients are in contact with many different health care providers. It is of utmost importance that all information provided by health care providers is complementary, in such a manner that contradictions are prevented, to limit confusion and anxiety. The therapist providing PNE should communicate with the other persons involved in the (para)medical care within the multi-/transdisciplinary setting, to ensure everyone is endorsing the same biopsychosocial framework.

Medication overuse

In clinical practice, opioids are often prescribed to patients undergoing lumbar surgery, with a dramatic increase in prescription rates for the management of low back pain over the past 10 years. PNE could possibly decrease opioid usage for postoperative pain, although there is no clear evidence yet. In patients with arthroscopic rotator cuff repair, opioid-related preoperative education revealed a significant decrease in the number of narcotic pills consumed at 3 months postsurgery. During the education session of the latter study, patients were informed about postoperative opioid usage, possible side effects of opioid use, opioid dependence, and addiction during a 2-minute video,
combined with a handout. Implementing a short discussion about opioid use during perioperative PNE in patients undergoing surgery for lumbar radiculopathy could possibly reveal similar effects.

**Conclusion**

The present clinical perspective provides guidance for physical therapists for applying perioperative PNE in patients undergoing surgery for lumbar radiculopathy. Perioperative PNE comprises a cognitive-based educational program that aims to teach patients about the neurophysiology of their pain—including the influence of cognitive, behavioral, and environmental factors—and to reassure them about their decision to have surgery, all based on a biopsychosocial framework. The desirable format for the education is one-on-one sessions supplemented by written educational material. However, if individual sessions are not feasible within the limitations of the particular health care system or clinical setting, the content can be transferred to group sessions.


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References


82. Louw A. *Your Nerves Are Having Back Surgery*. International Spine and Pain Institute, Louisville, KY, USA; 2012.


eAppendix

Questionnaire to be completed by the patient after the preoperative PNE session

Acute pain
Do you understand that pain is a normal part of the protection mechanism of our body?
  o Not at all
  o More or less
  o Completely

Do you have any other questions or remarks regarding this topic?

Pain and tissue damage
Do you understand the concepts “pain without damage” and “damage without pain”?
  o Not at all
  o More or less
  o Completely

To what extent do you think that your current leg pain is due to tissue damage in your leg?
  o Not at all
  o More or less
  o Totally

Does your pain evoke certain emotions?
  o Yes. Which emotions? ............................................................
  o No

Do you have any other questions or remarks regarding this topic?

Chronic pain
Do you understand that the pain system can become sensitized by unconscious training?
  o Not at all
  o More or less
  o Completely
Do you understand why a patient with chronic pain might experience pain due to stimuli that should not be experienced as painful?
  - Not at all
  - More or less
  - Completely

Cause of symptoms

When tissue healing will be completed post-surgery, will the degree of tissue damage than still play an important role in your symptoms?
  - Not at all
  - A Little
  - Yes, definitely

Do you think genetic predisposition has played an important role in the development of your symptom?
  - Not at all
  - A Little
  - Yes, definitely

Do you think your nervous system is sensitized at the moment?
  - Not at all
  - A Little
  - Yes, definitely

Do you suffer from negative emotions (e.g., anger, sadness, helplessness, ...)?
  - Not at all
  - A Little
  - Yes, definitely

Do you often experience mental stress?
  - Not at all
  - A Little
  - Yes, definitely

Do you often bottle up tensions, anger or sadness?
  - Not at all
  - A Little
  - Yes, definitely

Do you often ask too much from your body (e.g., keep going on, never resting, doing too many things at the same time)?
  - Not at all
  - A Little
  - Yes, definitely

Do you think you focus too much on painful body parts?
  - Not at all
  - A Little
  - Yes, definitely
What are according to you, the 3 most important reasons for your symptoms right now?
1. ........................................................................................................................................
2. ........................................................................................................................................
3. ........................................................................................................................................

Symptom timeline
How long do you think your symptoms will last? Why?
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........................................................................................................................................
........................................................................................................................................

What could you do to worsen your symptoms?
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What could you do to improve your symptoms?
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What could be the role of others in the timeline of your symptoms?
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........................................................................................................................................
........................................................................................................................................

To what extent do you think you understand your symptoms?
  o  Not at all
  o  A little
  o  Completely

If you imagine the future, which emotions does this evoke to you?
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........................................................................................................................................
........................................................................................................................................

Do you think your symptoms can cease with time? If so, to what extent?
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