

PAIN AND PROTECTIVE REFLEXES

Matti V.O. Närhi

Department of Physiology, University of Kuopio, Finland

Keywords: Idiopathic pain, inflammation, neuropathic pain, nociceptive pain, nociceptor, noxious stimuli, phantom pain, tissue damage, withdrawal reflexes.

Contents

1. Introduction
 2. Physiological and pathological pain
 3. Pain definition
 4. Classification of pain
 5. Central pain pathways
 6. Withdrawal reflex and avoidance behavior induced by noxious stimulation
 7. Regulation of pain transmission in the central nervous system
 8. Functional and structural changes in the pain tracts
 9. Responses of peripheral nociceptors to tissue injury and inflammation
- Glossary
Bibliography
Biographical Sketch

Summary

As a sensory experience pain is in general considered unpleasant and even unnecessary. In fact, we seldom think how important normal physiological pain and the related avoidance responses are with regard to the protection, health and existence of an individual. Traditionally, pain was thought to be a more or less direct indicator of tissue injury and the pain mediating neural pathways just like electric wires, which conduct the injury-induced nerve impulses to the brain to evoke a painful sensation. However, we know now that pain is not only a simple sensation, but it includes a complicated series of events, which consist of affective individual reactions to the noxious stimulus in addition to the sensory-discriminative components of the response. In addition to the sensory afferent functions the pain-mediating neurons have also important efferent effects in the regulation of the inflammatory reactions and tissue repair in the peripheral tissues. Advances in pain research during the past few decades have revealed that nerve impulse transmission at various levels of the pain pathway is regulated by a number of different control mechanisms. They can effectively attenuate, but in some cases also enhance the nerve impulse traffic and, in that way, modify the evoked pain response or even prevent it completely. Our concept regarding the development and mechanisms of pain has also changed significantly. Various pain conditions can be based on quite different neurobiological mechanisms. Many of them are actually caused by a malfunction of the pain mediation and regulation systems themselves. Accordingly, quite different strategies are needed in pain management. It is obvious that in the future, treatment of pain will be more targeted according to the specific pathophysiological basis of each pain condition.

1. Introduction

Our previous concept regarding pain was primarily based on the idea that the pain experience is directly related to and dependent on the existence and extent of clinically discernible tissue damage and, thus, also on the intensity of the noxious stimulus applied to the tissues. A consequence of such a concept was that, simply, the treatment and elimination of the tissue injury was the main goal in the treatment of pain. It was expected to result in abolition of the existing symptoms of any pain condition. In fact, such a principle is still valid in most cases of acute pain. However, progress in pain research during the past 20 to 30 years has revealed completely new insights regarding our knowledge on pain in general and the mechanisms and treatment of various pain conditions. As a result we know now that pain is not a uniform entity, but there are a number of pain conditions, based on quite different neurophysiological mechanisms. We also know that in connection with chronic pain the disorder may actually be located in the pain-mediating system itself, either in the periphery and/or in those central structures which regulate the pain impulse transmission. Already today and to an even higher extent in the future, the treatment of pain will, therefore, be more and more targeted according to the specific mechanisms of the given pain condition.

2. Physiological and pathological pain

The functionally normal healthy pain mediating system and physiological pain responses are essential for the protection of the individual against harmful external noxious influences which may induce tissue injury and be life threatening. As a response to such insults, a number of different withdrawal reflex and avoidance responses are activated; these all aim to protect the subject from more extensive injuries. In some unusual cases individuals have been born with deficient pain perception. The inability to feel pain and respond to noxious stimulation is a dangerous condition and results in great difficulties in every-day life. Serious tissue damage can be induced by external noxious stimuli without any pain or discomfort or activation of the normal avoidance behavior and withdrawal reflexes.

Individuals with normal pain perception try to avoid any noxious stimuli because pain experience is unpleasant. The reason is that the ascending pain pathways have keen connections to the limbic system in the brain. The limbic system regulates our emotions including the feelings of pleasantness and unpleasantness of any emotional experience. For the withdrawal reflexes and avoidance behavior the close connections of the pain tracts and the reticular formation (RF) in the brain stem are also important. Activation of the RF by external sensory stimulation, e.g. noxious stimuli, evoke an arousal response in the brain, which makes the individual more prepared for the avoidance of further tissue damage by increasing the attention and motor activity and inducing a “fight or flight” reaction. As a part of this response the autonomic nervous system is also activated and the firing of the sympathetic efferents results in an increase in heart rate and blood pressure.

Both acute and especially prolonged chronic pain activates those hypothalamic brain areas which regulate the autonomic nervous system and also endocrine secretion (e.g. stress hormones). These responses can explain the changes in various autonomic

functions as well as the existence of various psychosomatic symptoms, which may be connected to chronic pain conditions. Altogether, pain has widespread effects on the brain, which can explain why the pain experience can be so overwhelming. Long-lasting pain can also result in a total change in behavior and way of life of an individual. In fact, as a result a learned chronic pain behavior pattern may develop and the pain condition can finally become a main focus in the patient's life. In such cases the originally physiological pain symptoms usually develop into a pathological chronic pain condition within a few months or years.

3. Pain definition

As defined by the International Association of the Study of Pain “Pain is an unpleasant sensory and emotional experience related to an actual or potential tissue damage or described in terms of such a damage”. Accordingly, pain is not just a simple sensation but instead, a more complex, subjective experience. It also includes the subject's reaction to a noxious stimulus. The definition also recognizes that although pain, in principle, results from a tissue injury, the extent of the injury and the intensity of the pain symptoms are not necessarily directly correlated. In fact, there are cases with extremely intense pain without clinically discernable tissue injury. Because pain experience is highly subjective and emotional, its measurement is also complicated.

-
-
-

TO ACCESS ALL THE 18 PAGES OF THIS CHAPTER,
Visit: <http://www.eolss.net/Eolss-sampleAllChapter.aspx>

Bibliography

Bear M.F., Connors B.W. and Paradiso M.A. (2001). *Neuroscience*. 2nd edition. Lippincott, Williams and Wilkins. [This book gives a comprehensive presentation of the structure and function of the nervous system].

Byers M.R. and Närhi M. (1999). Dental injury models: Experimental tools for understanding neuroinflammatory interactions and polymodal nociceptor functions. *Critical Reviews in Oral Biology and Medicine* 10, 4-39. [This review presents new results as regards to both the afferent and efferent functions of the primary nociceptive neurons in inflammation and tissue repair processes in injured tissues].

Guyton A.C. and Hall J.E. (2000). *Textbook of Medical Physiology*. 10th edition. N.B. Saunders, Philadelphia. [The book describes the functions of various tissues, organs and the body as a whole].

Melzack R. and Wall P.D. (1965). Pain Mechanisms: A New Theory. *Science* 150, 971-979. [This is a milestone paper in the field of pain research and presents the original theory of pain regulation in the spinal cord].

Nagasako E.M., Oaklander A.L. and Dworkin R.H. (2003). Congenital insensitivity to pain: an update. *Pain* 101, 213-219. [This review article covers the current knowledge on the deficiencies of the pain mediation system and their consequences].

Nikolajsen L., Hansen C.L., Nielsen J., Keller J., Arendt-Nielsen L. and Jensen T.S. (1996). The effect of ketamine on phantom pain a central neuropathic disorder maintained by peripheral input. *Pain* 67, 69-77. [This paper presents clinical trials testing the efficacy of ketamine, a NMDA receptor antagonist, in the treatment of neuropathic pain].

Olgart L. (1996). Neurogenic components of pulpal inflammation. In: *Dentin/Pulp Complex* (Editors: Shimono M., Maeda T., Suda H. and Takahashi K.), pp. 169-175. Quintessence, Japan. [In this review various peripheral mechanisms regulating the nociceptor function are discussed].

Price D.D., Mao J., Frenk H. and Mayer D.J. (1994). The N-methyl-D-aspartate receptor antagonist dextrometorphan selectively reduces temporal summation of second pain in man. *Pain* 59, 165-174. [The authors have examined the effect of a NMDA receptor antagonist on experimental pain in human subjects].

Rappaport Z.H. and Devor M. (1994). Trigeminal neuralgia – the role of self-sustaining discharge in the trigeminal ganglion. *Pain* 56, 127-138. [In this review the pathophysiological mechanisms of neuralgic pain are discussed].

Sessle B.J. (2000). Acute and chronic craniofacial pain: Brainstem mechanisms of nociceptive transmission and neuroplasticity, and their clinical correlates. *Critical Reviews in Oral Biology and Medicine* 11, 57-91. [The author gives a comprehensive description of and discusses the neurobiological mechanisms in the development of various chronic pain conditions especially in the orofacial area].

Wall P.D. and Melzack R. (1999). *Textbook of Pain*. 4th edition, Edinburgh: Churchill Livingstone. [In this textbook various aspects of pain from the neurobiological background to the clinical pain conditions and their treatment are described].

Biographical Sketch

Närhi, Matti V.O. was born in April 1951, in Helsinki, Finland. He is a Research Director, University of Kuopio, Kuopio, Finland.

Qualifications: DDS, University of Helsinki, 1975, Ph.D. (Physiology), University of Helsinki, 1979

He has served as:

- Lecturer, Instructor and Professor in Medical and Oral physiology, University of Helsinki, University of Kuopio and University of Turku, Finland, 1973-
- Docent in Oral Physiology, University of Kuopio, Finland, 1982-1988
- Docent in Physiology, University of Helsinki, Finland 1986-
- Docent in Oral Biology, University of Kuopio, Finland 1988-
- Professor and Chair of Pain Physiology, University of Turku, Turku, Finland, 1998-2002
- Docent in Pain Physiology, University of Turku, Turku, Finland, 2002-

Research Activities:

Leader of the research project: “Neurophysiological and anatomical basis of orofacial pain”. The research activities of the project include electrophysiological recording of the neuronal activity in the pain pathways both in the periphery and in the central nervous system, morphological studies of the dental structures related to pain mediation, human experiments using various pain models in the laboratory as well as clinical studies on dental pain.

Publications:

- He has published 72 original and review articles on various aspects of orofacial pain mechanisms.
- Honors and Awards:

- Research Grants and Fellowships from Academy of Finland, Medical Research Council, 1978-1988
- Advanced Scientist Research Fellow of the Finnish Dental Society, 1988
- IADR Distinguished Scientist Award in Pulp Biology, 1993
- MRC Visiting Professor, University of Toronto, Canada, 1993-1994
- Physiologist of the Year in Finland, nominated by the Finnish Physiological Society, 1998

Editorial Board Membership:

- Journal of Dental Research 1999-2000, 2002-
- Archives of Oral Biology 2002-
- Proceedings of the Finnish Dental Society 1991-1993 (Editor-in-Chief)