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Pain – Definition and Physiology

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ABSTRACT

Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage. For a stimulus to be painful, it must be perceived consciously and found to be unpleasant. To describe how pain is transmitted from the site of stimulation to the parts of the brain responsible for conscious awareness, the term nociception is used. A nociceptive stimulus is one which will be felt as painful if and when it reaches the conscious parts of the brain. Nociceptors (pain receptors) are located throughout the body. Some are specific for pain whilst others are sensitive to things (like hot or cold) which may or may not be painful depending on the intensity. Two kinds of pain are transmitted to the central nervous system. The first is pin-prick pain. This is mild, specific to an area and is transmitted rapidly. The second is true pain. This can be severe, is only poorly localised and is transmitted to the central nervous system slowly. Pin-prick pain is the sensory arm of a valuable protective mechanism which alerts the animal to the presence of things which may cause injury. True pain can affect the function and psychological state of the whole animal and is a significant welfare issue if it is severe or prolonged. The first step in dealing with pain in animals is to recognise it. Animals are not able to communicate verbally and so cannot describe their feelings. In order to assess pain, we are forced to make assumptions about how the animal is feeling from its behaviour or physical responses. For example, if a cow is lame, it may be reluctant to walk, lame on the painful leg when it must walk, and show physiological changes in its nervous and endocrine systems. If the pain is prolonged or severe, the animal may become depressed, lose weight and show reduced productivity. Because the animal cannot say "my leg hurts", people working with animals have a responsibility to look out for signs of pain and to investigate their underlying cause.

Keywords: pain physiology; animal welfare.

INTRODUCTION

Pain has been defined by the International Association for the Study of Pain (IASP) as follows:

> Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage (Merskey & Bogduk, 1994).

The full IASP definition includes footnotes which state that pain is always subjective and is not tied to a particular stimulus and that the inability to communicate pain does not negate the possibility of experiencing pain. This means that, for a stimulus to be painful, it must be perceived consciously and found to be unpleasant by the organism perceiving the stimulus.

Conscious perception occurs in the higher centres of the central nervous system, but a stimulus which will eventually be perceived as painful must originate from the tissues which have been stimulated. Such a stimulus will be transmitted through the nervous system to the conscious centres as a nerve signal which is not yet pain, but will become pain when it reaches conscious awareness. To avoid confusion, these stimuli are referred to as noxious stimuli. The signal which results from a noxious stimulus is said to be nociceptive. A nociceptive signal is only called painful if and when it reaches the conscious parts of the brain.

Nociceptors

Nociceptors (pain receptors) are located throughout the body, but are more numerous in some tissues than others (Guyton & Hall, 1996). Some are specific for pain whilst others are sensitive to other modalities (like hot or cold) which may or may not be painful depending on their intensity. Nociceptive pathways broadly divide into two populations called somatic (Latin - of the body) and visceral (Latin – of the entrails) which respond to different kinds of stimuli and transmit their signals to the central nervous system by different routes. Somatic nociceptive pathways respond to extremes of heat, cold and pressure as well as to cutting or stretching. The nervous impulses are carried in sensory nerves which relay other sensory information from the body. Somatic nociceptors are concentrated in the skin, conjunctiva and mucous membranes of the mouth and nose as well in the joints and the periosteum. Visceral nociceptive pathways respond only to stretching. The nervous impulses are carried with the nerves of the autonomic nervous system. Visceral nociceptors are concentrated in the walls of hollow organs such as the stomach and intestines.

Somatic Pain

The somatic pain pathways include two different pain sensations, both of which are transmitted to the central nervous system. The first is often referred to as pin-prick pain. The characteristics of pin-prick pain are that it is mild, well localised to a small area, transmitted rapidly to the central nervous system and that the feeling of pain does not outlast the stimulus. The sense of pin-prick pain can easily be elicited by pressing a finger against a pointed object such as a key with gradually increasing pressure.

As the pressure increases this information is relayed to the central nervous system as an increased intensity of feeling. The feeling becomes more and more intense until suddenly it becomes perceived as pain. If the key is removed as soon as pain is felt, the sensation of pain disappears almost instantly. This is pin-prick pain.

True pain can be severe, is only poorly localised and is transmitted to the central nervous system slowly. The sense of true pain can easily be elicited by such actions as striking the thumb with a hammer. The blow is felt almost immediately and is mildly painful with the pain emanating from the thumb (pin-prick pain). A few seconds later, the nature of the pain changes, it becomes much more intense and unpleasant and appears to emanate from the whole of the hand or even lower arm. The sensation of pain lasts much longer than the stimulus. This is true pain.

Pin-prick pain is the sensory arm of a valuable protective mechanism which alerts the animal to the presence of things which may cause injury. The reflex response to pin-prick pain is limited to withdrawal of the affected area whilst the animal's attention becomes focused on the area from which the stimulation arose. The initial response to true pain is much more dramatic, with a very exaggerated withdrawal of the whole limb or even side of the body, the expression of pain related behaviours and even alterations of metabolic and emotional state. True pain can affect the function and psychological state of the whole animal and is a significant welfare issue if it is severe or prolonged.

Visceral Pain

Visceral pain always has the characteristics of true pain. In addition to being poorly localised, it often appears to emanate from an area of the surface of the body which may or may not be close to the true origin of the pain. Pain which appears to come from a different origin to the location of the stimulated receptors is called referred pain. A good example of referred pain is the pain of acid indegestion which is often felt as a burning sensation over the left side of the chest and throat. Flank watching in horses suffering from colic may also be due to referred pain.

Hyperalgesia and Allodynia

The sensation of pain is not always the same for a given stimulus. The perception of pain and its effect on the animal will depend on many factors.

Hyperalgesia and allodynia are terms used to describe increased sensations of pain. If a stimulus that would normally be painful is perceived as more than usually painful, the animal is said to be hyperalgesic. Allodynia is the perception of pain following a stimulus which would not normally be painful. A good example of hyperalgesia and allodynia is a sprained ankle. If the ankle is stretched to a degree that would normally be painful, it is even more painful than usual. This is hyperalgesia. Walking normally on the ankle is itself painful. This is allodynia.

Mechanisms of Hyperalgesia and Allodynia

Variations in the sensation of pain are due to alterations in function at many levels in the nociceptive pathways. The two most important are alterations in the sensitivity of nociceptors within the tissues and plasticity within the central nervous system.

The threshold at which nociceptors will respond to a noxious stimulus can be altered by chemical mediators. Many chemicals that are found in inflamed and damaged tissues can act to sensitise nociceptors. These include eicosanoids, histamine, bradykinins and other chemicals (Livingston & Chambers 2000). This local sensitisation is restricted to the immediate area of inflammation.

Central nervous system plasticity occurs at many sites in the nociceptive pathway and alters the perception of pain from the injured area and also from other parts of the body. After a prolonged period of stimulation, the central nervous system becomes more sensitive to pain and hyperalgesia and even allodynia can occur. This process is referred to as wind up and is due to many neurological and metabolic changes that occur over time.

Other factors, such as the presence of non-painful stimuli and the emotional state of the animal, can affect pain sensation. A barrage of touch or vibration stimuli from close to a painful area can reduce the sensation of pain. This is why rubbing the hand can reduce the pain from a finger and is thought to be why some acupuncture techniques are analgesic. This reduction in pain caused by other stimuli is referred to as the gate theory of pain control (Melzack & Wall, 1965). The other stimuli act to "close the gate" on the nociceptive pathway and so limit the degree of pain.

Certain emotional states of arousal can also alter the perception of pain. Sportsmen often do not notice minor injuries until some time after their occurrence because they were in a state of excitement during the event. Depression can increase the degree of pain felt and since chronic pain can itself cause depression, this can lead to a vicious circle of spiralling pain in sufferers of chronic and painful conditions such as arthritis.

Recognition of Pain

The first step in dealing with pain in animals is to recognise it. Animals are not able to communicate verbally and so cannot describe their feelings, however the nociceptive pathways of the domestic mammals are very similar to those found in man. For this reason it is usually assumed that any activity in these pathways gives rise to unpleasant feelings of pain that are similar to those felt by people.

Animals and people respond to pain in specific ways. Some of these, such as the electrical and chemical response of the brain, are similar across the species and some, such as behaviour, have elements that are specific to a particular species (Dobromylskyj *et al.,* 2000). Pain-related behaviour can even vary across breeds or cultural groups. When assessing an animal's pain, it is essential to be familiar with the normal behaviour of that particular kind of animal in its particular environment. Any behaviour shown by an individual that is either unusual or not shown by other animals in the group should be regarded with a high index of suspicion as being pain-related. In order to assess an animal's pain, we are forced

to make assumptions about how the animal is feeling, which'should be based on its behaviour, physical responses, or, preferably, a combination of these.

Implications of Pain for Animal Welfare

If a cow is lame, it may be reluctant to walk. It may be lame on the painful leg when it must walk and show physiological changes in its nervous and endocrine systems. If the pain is prolonged or severe, the animal may become depressed, lose weight and show reduced productivity. The lame leg will become progressively more painful as the nociceptive pathways become sensitised, the pathology causing the lameness progresses and the animal becomes more depressed. Because the animal cannot say "my leg hurts", people responsible for its care have an even greater obligation to look out for signs of pain and to investigate and treat both the pain and its underlying cause.

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