

Pain in domestic animals and how to assess it: a review

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ABSTRACT: In recent years more attention has been paid to the issue of pain in animals, particularly in association with increasing awareness of animal welfare. It is therefore necessary for veterinarians to be able recognise unambiguously whether an animal suffers from pain. Adult humans suffering from pain can more or less characterise their painful experiences, including the site and intensity of the pain. However, pain in animals is in some aspects more complex and it can be rather difficult to evaluate the seriousness and impact of painful events. Therefore, in animals we have to recognise the signs of pain according to indirect markers which involve behavioural, physiological and finally clinical responses. Moreover, in particular the behavioural changes associated with pain can be along with the general signs also species-specific, and hardly recognisable (and for an inexperienced observer seemingly unimportant) which makes pain assessment even more complicated. Therefore, the current review formulates definitions of pain, its classification and is focused on methods that may facilitate pain recognition in animals, which is crucial for an effective pain assessment and consequent effective pain management. The review combines recent knowledge with well proven facts concerning pain and furthermore also highlights the author's own research on pain assessment.

Keywords: painful responses; animal pain; physiology; clinics; behaviour

List of abbreviations

CNS = central nervous system, EEG = electroencephalogram, HPA = Hypothalamo-Pituitary-Adrenal Axis, IASP = International Association for the Study of Pain, RIA = radioimmunoassays, VAS = visual analogue scale

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1. Introduction

It is difficult to define pain generally; nevertheless, some attempts have been made. Pain is an expression that originally describes experiences in humans. One of the most concise definitions of pain was published by the International Association for the Study of Pain (Anonymous 1979). In their

formulation, "pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage". There is, however, continuing discussion about the revision of this definition (Anand and Craig 1996).

Although it is not clear if animals and humans experience the same sensation, it is assumed that

animal pain serves the same purposes as human pain. If we accept this, it enables us to define animal pain more easily (Sanford et al. 1986). In other words, in response to painful stimuli animals have sensory experiences which change their biochemistry, physiological parameters and behaviour and they try to avoid such stimuli in future (Sanford et al. 1986).

Thus, there are two definitions which are frequently cited to describe pain in animals:

(1) 'Animal pain is an aversive sensory experience that elicits protective motor actions which result in learned avoidance and may modify species-specific traits of behaviour including social behaviour' (Zimmermann, 1986).

(2) 'Animal pain is an aversive sensory and emotional experience representing an awareness by the animal of damage or threat to the integrity of its tissues; (note, that there may not be any damage) it changes the animal's physiology and behaviour to reduce or avoid damage, to reduce the likelihood of recurrence and to promote recovery; non-functional pain occurs when the intensity or duration of the experience is not appropriate for the damage sustained (especially if none exists) and when physiological and behavioural responses are unsuccessful in alleviating it' (Molony 1997).

Despite scientific evidence suggesting unambiguously that vertebrate animals of various species are susceptible to painful events in a very similar manner (Short 1998), it should be mentioned here that not all accept this finding. For example, farm animals may show no major apparent symptoms when in pain because such individuals (sick or injured) are more prone to predation; thus, hiding signs of painful events has become a strategy of survival in many species (Underwood 2002).

Henke and Erhardt (2001) advanced a theory concerning the differences in people's attitudes regarding the ability of sensing pain in various animal species. The authors suggested that communities attribute to different species distinct abilities of pain perception according to their own "ethical" hierarchies. These hierarchies hold primates or pets to be creatures that can experience pain and suffer in terms of the human sensation because primates are to a large extent similar to people and there are emotional attachments to pets. The same is not true, however, in the case of domestic animals such as cows, sheep or pigs. These animals are from the general point of view intended for food production and thus "logically" their ability

to experience pain must be decreased (Henke and Erhardt 2001). Hopefully, there is no need to emphasise, that people educated in biological science and veterinarians in particular should avoid this attitude. It is heartening that recent papers report, probably in association with the increasing interest in animal welfare, that even pain in farm animals such as cattle evokes sympathy in people (Wren, 2007).

Significant progress in finding alternatives to laboratory animals in medical and other research has been made over the last years (Carbone 2011). It is, however, unlikely that the use of domestic animals will follow the same course. Thus, it is also essential to respect the rights of these animal species, particularly their right to live free from pain and suffering, in accordance with the Farm Animal Welfare Council's Five Freedoms: 'Freedom from Pain, Injury or Disease – by prevention or rapid diagnosis and treatment' (Fitzpatrick et al. 2006).

Although in companion animals successful pain management is becoming widespread, it has been reported that farm animals are frequently given no analgesic drugs for treatment of a whole range of unambiguously painful procedures such as tail docking in pigs, sheep and cattle (Sutherland and Tucker 2011), castration in male calves, sheep, pigs (Coetzee 2011; Rault et al. 2011) or dehorning in cattle (Stafford and Mellor 2011) – for a more detailed review see Walker et al. (2011). Therefore, this paper is intended as a modest contribution to the issue of pain in domestic animals, especially to its recognition and assessment, and it is partly based on the personal experiences of the author.

2. Classification of pain according to sites of origin and duration

Painful states are caused particularly by tissue or nerve damage, inflammatory processes, viral infections or demyelination and are characterised by pain hypersensitivity (Vinuela-Fernandez et al. 2007).

Somatic pain originates in the skin and is called superficial pain. If it originates in the muscles, bones, joints or connective tissues it is called deep pain. In other words somatic pain refers to pain originating from the periphery and can be in most cases be well localised (Robertson 2002).

Visceral pain arises from viscera (Joshi and Gebhart 2000). McMahon et al. (1995) suggested

that the sensitivity of viscera to mechanical, thermal or chemical stimuli is very different. Viscera are predominantly sensitive to distension of hollow muscular-walled organs and to inflammatory processes. Visceral pain can moreover be referred to another part of the body. Information from certain regions of viscera converges on spinal cord neurones and pathways that also convey information from somatic structures. For example, some cows exhibit an extreme sensitivity in the region of the sternum when they suffer from traumatic peritonitis caused by a wire or nail perforating the wall of the forestomach (Fransson et al. 2009). Visceral pain is usually described as more diffuse and unpleasant than somatic pain (Paine et al. 2009) and the diffuse nature of true visceral pain is probably caused by the low density of visceral sensory innervation and extensive divergence of the visceral input within the CNS (Giamberardino and Vecchiet 1997).

Neuropathic pain originates within the nervous system itself and arises as a disorder of processing of nociceptive activity or as a result of abnormal activity in nociceptive pathways (Lamont et al. 2000). It is known as a pathological painful condition in which nociceptive responses last beyond the resolution of damage to the nerve and the surrounding tissues. Neuropathic pain is typically manifested by disproportionate hypersensitivity to stimuli (hyperalgesia), abnormal pins and needles sensations (hyperpathia), and nociceptive responses to harmless stimuli (allodynia) (Leung and Cahill 2010).

Acute pain soon disappears once the damaged tissue has been healed. In contrast, chronic (or persistent) pain lasts beyond the expected healing time for an injured tissue (Molony and Kent 1997) and can be more difficult to recognise, because it is not possible to identify behaviour that would uniquely and reliably indicate the existence of chronic pain (Mogil and Crager 2004).

It is also important to realise that various tissues and organs of the body can have different sensitivities to painful stimulation. For example, mucous membranes, cornea or dental pulp are considered to be extremely sensitive, whereas parenchymatous organs are characterised as less painful (Henke and Erhardt 2001).

3. Assessment of pain in animals

Whereas it is possible to assess pain in humans directly usually using a rating scale scored by the

subject, this is not possible in animals. In animals informative signs must be studied to glean this information (Sanford 1992). Similar problems have been addressed in prelingual children (McGrath et al. 1985) or in non-verbal patients (Herr et al. 2006). Indirect symptoms that can serve as indicators for assessment of pain in animals include changes in both physiological and behavioural parameters (Molony and Kent 1997). In addition to physiological and behavioural parameters clinical responses can facilitate the assessment of pain (Morton and Griffiths 1985).

4. Responses to pain

4.1. Physiological responses to pain

The main glucocorticoid hormone that is released in response to stresses including pain is cortisol (Hecter and Pincus 1954). The corticosteroid level can be measured in plasma or saliva and is a widespread means for the physiological assessment of the activity of the Hypothalamo-Pituitary-Adrenal Axis (HPA) which is activated in painful conditions (Molony and Kent 1997). The measuring of cortisol has been used in animals to estimate the effects of different painful procedures such as abdominal surgery (Pearson and Mellor 1975), electroimmobilisation (Jephcott et al. 1986, 1987) and castration (Mellor and Murray 1989a,b). Samples of blood are usually collected from the jugular vein and for estimation of cortisol levels radioimmunoassays (RIA) are common (Shutt et al. 1988; Mellor and Murray 1989b; Graham et al. 1997). Plasma cortisol levels in groups of animals undergoing painful stimulation are compared with control groups of animals which are without pain, and just handled.

However, there are some limitations to the use of corticosteroid levels for assessment of animal pain: plasma cortisol concentrations can depend on circadian rhythms (McNatty et al. 1972; Gardy-Godillot et al. 1989), and there are periodic fluctuations (Tapp et al. 1984) and other events which might not necessarily be associated with pain (Colborn et al. 1991). It is moreover necessary to make a series of plasma cortisol measurements before and after treatment to estimate the changes (Molony and Kent 1997). Kent et al. (1993) found that changes in plasma cortisol concentrations corresponded with some types of behavioural changes after castration and tail docking. Weary et al. (2006)

noted that measurements of physiological parameters can require the restraint of animals and tissue sampling, which can also be stressful and may influence the results.

Despite these caveats, the assessment of plasma cortisol levels remains a well-proven and common method for pain evaluation, e.g., together with plasma adrenocorticotropin hormone (ACTH) concentrations, and measurements of plasma glucose and plasma lactate (Prunier et al. 2005; Mormede et al. 2007; Keita et al. 2010).

Prunier et al. (2005) used lactate measurements to reveal the metabolic processes taking place during pain. Catecholamines are produced in response to stressful events (including pain) and this results in an increase in glycogenolysis and mobilisation of glycogen, predominantly from muscle tissue, and as a consequence an increase in lactate and glucose production.

In addition to cortisol parameters, Shutt et al. (1988) and Mears and Brown (1997) used changes in plasma immunoreactive beta-endorphin as an indicator of pain by means of RIA.

Some attempts have also been made to connect pain (caused by castration of male pigs) with fluctuations in the levels of tumour necrosis factor- α , interleukin-1 β , C-reactive protein, serum amyloid A and haptoglobin in blood; however no changes in the levels of these substances were revealed (Moya et al. 2008).

4.2. Clinical responses to pain

Besides measuring the activity of the HPA system it is possible to make measurements of the activity of the sympathetic nervous system flow (Molony and Kent 1997). This includes changes in the cardiovascular system (altered heart rate, changes in pulse quality, and decrease in peripheral circulation), respiratory system (abnormal breathing pattern, altered rate and depth), pupillary diameter, skin resistance or peripheral blood (Morton and Griffiths 1985). As animals in pain frequently have an elevated heart and respiration rate and a reduced blood supply to the extremities, Morton and Griffiths (1985) suggested that these parameters be examined. In addition to these measurable clinical signs of pain they recommended, e.g., the estimation of body weight because weight loss could indicate reduced food intake which could be caused by pain. They also recommended checking the quality

and quantity of faeces. This would help in assessing the function of the digestive system, which could also be affected by pain. However, there are also limitations to this type of assessment and the mentioned changes and signs may not necessarily be caused by pain (Sanford 1992).

Attempts have also been made to measure and study pain in humans using an electroencephalogram (EEG) which can reflect changes in brain electrical activity (Michels et al. 2011), and there is an increasing number of papers that describe the use of EEG in animals (Diesch et al. 2009; Gibson et al. 2009; Johnson et al. 2009). However, EEG also has its own specific methodological and interpretative limitations. Artefacts caused by movement may occur and there are particular difficulties in locating pain centres in the brain and separating pain responses from motivational states such as fear or anxiety (Barnett 1997). Nevertheless, Johnson et al. (2005) have demonstrated in their work with farmed deers, that EEG can identify reactions to pain even if there are no apparent behavioural changes in restrained animals.

As one example of a clinical species-specific response to pain could be mentioned sweating (to the point of dehydration) in horses (Goodrich and Mama 2011).

4.3. Behavioural responses useful for assessment of animal pain

Morton and Griffiths (1985) proposed that the study of behavioural patterns should constitute a substantial part of pain assessment. They tried to define species-specific signs of behaviour indicating pain. For example, they described some types of behaviour in dogs that was associated with pain. These included changes in posture (anxious glances, tail between legs), vocalising (howls, distinctive bark), changes in temperament (aggression or cringing and extreme submissiveness) and other changes (penile protrusion and frequent urination and defecation).

Thornton and Waterman Pearson (1999) used visual analogue scale (VAS) scores which were based on the scheme of Morton and Griffiths (1985) for the assessment of pain responses in castrated lambs. Beside VAS, Thornton and Waterman Pearson (1999) used mechanical nociceptive threshold responses, plasma cortisol concentrations and a continuous scoring system. The

VAS continuous scoring system used a horizontal straight line 100 mm long with the left side marked as 'no pain whatsoever' and the right side 'the worst possible pain'. The observer marked this line with crosses according to how severe the pain was in their estimation. Crosses on the scale were then translated into a numerical score by measuring (in mm) from the left anchor.

There exist certain species-specific behavioural changes that can be measured and quantified. For example Molony and Kent (1997) used for the behavioural assessment of pain in lambs changes in posture and locomotor activity. As changes in posture they recognised lying and standing. These postures were divided further into normal lying (ventral, sternal) with the head down (V1) or with the head up (V2) and abnormal lying ventral with one partially extended leg (V3) or with full extension of one or more hindlimbs (V4). In addition to ventral lying Molony and Kent (1997) distinguished lateral lying with a shoulder on the ground and the head up (L1) or down (L2). Standing postures were also divided into normal standing or walking (S1), abnormal standing or walking with moderate ataxia, swaying or abnormal stance (S2), severe abnormal standing or walking with stilted gait, walking on knees or walking backward (S3) and immobile standing (SS). As changes in locomotor activity Molony and Kent (1997) suggested increased restlessness, kicking, stamping, rolling, jumping, easing quarters, licking or biting at the damaged site and tail wagging. Some of these behaviours are considered to have no beneficial effects; however, they can be described as attempts to escape and may be interpreted as specific pain behaviour (Molony and Kent 1997). This methodology was successfully used for estimation of behavioural responses to the pain of castration in calves (Molony et al. 1995) or tail docking in lambs (Landa 2003).

More recently Leslie et al. (2010) reported behavioural changes that can be used for the assessment of acute pain in piglets undergoing ear tagging or notching. These procedures produced pain-related behaviour like head shaking (e.g., vigorous toss of head from side to side, flapping of ears), ear scratching (e.g., rubbing against the floor or the sides of the crates), vocalisation (e.g., squeal or grunting - more guttural forms of vocalisation) and finally shivering (trembling as though cold).

Another very recent and novel attempt to assess pain in horses was made by Love et al. (2011). They tried to determine changes in facial expressions dur-

ing a brief painful stimulus using kinematic analysis of facial movements. Horses undergoing IV catheter placement or IV injection were given reflective markers on the eyelids, nostrils, facial crest and midline and an infrared motion capture system was used for recording the positions of the markers. This technique was successfully used for measurement of facial muscle movements and although further research is required, changes in facial expression due to pain represent a very interesting and original approach to pain assessment in horses.

Examples of equid-specific behavioural indicators of pain originating from various parts of the body include deep groaning, rolling, kicking at abdomen, stretching, limb guarding and many others (for a review see Ashley et al. 2005).

4.4. Validation of the behavioural methods for assessment of pain

Although it is possible to use behavioural responses to painful stimuli for assessment of pain in animals these indices have certain limits. Firstly, the validation and recognition of changes in behaviour related to pain are dependent on the training and experience of the observer (Sanford 1992) and any person who uses behavioural parameters should be to a certain extent familiar with the personality of the animal that is subjected to pain assessment (Bufalari et al. 2007). Secondly, responses of various species to the same procedure can differ considerably. Thirdly, even individual animals of one species can show significant differences in responsiveness to painful stimulation as is the case in humans (Sanford 1992). This is known in horses, dogs, cats and primates and it is believed that it can occur in other species (Sanford 1992). As a possible solution, the estimation of pain using behavioural indices should involve discussion and agreement in methods and training of the person who carries out the observation so that they can recognise and distinguish abnormality and normality (Sanford, 1992). In order to minimise misinterpretation, physiological parameters can be used together with behavioural ones.

5. Conclusions

Particularly in the last two decades, considerable progress has been made in research concern-

ing pain in animals. As described above there are now methods for assessing pain in animals which could lead to more effective pharmacological or non-pharmacological pain management and to a substantial improvement in animal welfare.

6. Acknowledgements

The author thanks the Royal Society for the Prevention of Cruelty to Animals (UK) for the financial support, which enabled him to undertake research on pain assessment and to Ms. Joyce Kent (University of Edinburgh) for assistance with a substantial part of the text.

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Received: 2012–02–07

Accepted after corrections: 2012–04–20

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