Recognition and Management of Pain in Cattle

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Abstract

ATTITUDES towards pain and its control in farm animals have lagged behind those in companion animal species. However, a considerable amount of work over the past 15 years has focused on the perception of pain in cattle based on objective and subjective assessment by clinicians working with this species. A recent large-scale survey of cattle practitioners revealed that over half of the respondents felt their knowledge of pain and analgesia in cattle was inadequate or could be improved, and the majority of these identified a lack of readily available information on the subject as being a contributory factor. This article reviews current knowledge on pain assessment in cattle in a clinical setting, and discusses some protocols for pain management in specific conditions.

Introduction

Pain in humans has been described as "an unpleasant sensory and emotional experience with actual or potential tissue damage". It is reasonable to suppose that animals experience pain in a similar way to humans because experimental work has demonstrated that the neural pathways of pain sensation are similar in human and other mammals. Application of the "precautionary principle" would also suggest that this is the safest assumption unless strong experimental evidence proves otherwise. Attitudes towards pain and its control in farm animals have lagged behind those in companion animal species. However, a considerable amount of work in recent years has focussed on perception of pain in cattle by clinicians working with the species, and on its subjective and objective assessment.

In a recent large-scale survey of cattle practitioners (Huxley and Whay 2006), over half of respondents felt that their knowledge of pain and analgesia in cattle was inadequate or could be improved, and the majority of these identified a lack of readily available information on the subject as a contributory factor. This article reviews current knowledge on pain assessment in cattle in a clinical setting before discussing methods to prevent and alleviate it.

The Physiology of Pain

Pain results from by chemical, mechanical or thermal stimulation of free nerve endings containing nociceptors. Injury to cells in tissues causes release of inflammatory mediators (e.g. prostaglandins, histamine and bradykinin), which stimulate nociceptors in nearby nerve endings. This is an amplification process; a stimulus affecting a relatively small number of nerve endings stimulates many more. Impulses resulting from this stimulation are conducted via the ventrolateral part of the spinal cord to the brainstem and thalamus. There is further amplification at this level (centrally); this is known as "wind-up". Conscious perception of pain is a result of activation of certain areas of the cerebral cortex (via the thalamus). Theoretically, pain is a central "experience" that occurs as a result of nociception in peripheral nerves.

Tissue injury results in acute pain, which stimulates muscular action to avoid the noxious stimulus (either as a result of reflex limb flexion or via conscious mechanisms) and causes sympathetic autonomic nervous system activation and a heightened state of arousal. Increased sympathetic tone can become persistent if the insult is prolonged or severe. In chronic pain, the presence of high levels of inflammatory mediators around the site of injury and persistent activation of pain fibre pathways in the spinal cord leads to a decrease in pain threshold, so that stimuli are perceived as more painful than would be normal for the individual concerned. This is known as hyperalgesia. Another phenomenon associated with chronic pain is allodynia, whereby similar mechanisms lead to perception of normally non-painful stimuli as painful. Prevention or modulation of hyperalgesia and allodynia is one of the main objectives of analgesia. For example, a chronically lame cow may over time perceive the lesion as more painful than it was initially (hyperalgesia) and perceive pain in undamaged surrounding tissues on touch (allodynia).

As well as implications for welfare, pain is also significant in terms of disease progression, potentially having a major effect on the physiological state of the animal (Otto and Short 1998). This may interfere with wound healing.

Assessment and Recognition of Pain in Cattle

A large volume of research has been conducted in the past 15 years in the field of pain assessment in ruminants. A number of methodologies have been employed experimentally to assess or quantify levels of pain experienced by animals. These can be broadly categorised as objective and subjective. Objective methods measure physiological stress responses (e.g. plasma cortisol levels), changes in levels of biochemical markers (e.g. acute phase proteins) or the incidence of clearly defined behaviour patterns (e.g. vocalisation). Subjective methods are value judgements made by the human observer. These will become more repeatable and reliable with appropriate experience and training. Subjective pain assessment relies on the evaluation of behaviour, posture and other cues. The degree of pain is then either described using a verbal descriptor (e.g. mild, moderate, severe), assigned a numerical value (e.g. zero to 10) or described using a visual analogue scale (e.g. placement of a mark somewhere on a line between no pain and the worst pain imaginable).

In a practical situation, a variety of subjective indicators can be employed to assess pain, and this should form part of a standard clinical examination. The following indicators are useful in cattle:

- Decrease in movement/locomotion
- Decreased interaction with other animals in the group
- Decreased feed intake (e.g. "hollow" left flank caused by an empty rumen)
- Changes relevant to the source of the pain being experienced (e.g. altered locomotion, flank watching or kicking, ear twitching)
- Level of mental activity/responsiveness (animals in severe pain often show reduced responsiveness to stimuli)
- Changes in normal postures associated with pain (e.g. lateral recumbency, standing motionless, drooping of the ears)

- Easily measurable indicators of physiological stress (e.g. increased heart rate, increased pupil size, altered rate and depth of respiration, trembling)
- Bruxism (tooth grinding)
- Poor coat condition (e.g. rough, dusty or unkempt) caused by decreased grooming

As with all types of clinical examination, it is important to have a consistent approach to pain assessment, and ensure that the same behavioural and physiological signs are assessed in each animal.

It is important to remember that cattle are stoical by nature because, as a species, they have been subject to a strong evolutionary pressure to mask pain and its implied weakness from predators. As a result they often do not demonstrate appreciable definite signs of pain until the stimulus is severe. Often, particularly in adult cattle, unwillingness to move may be the predominant indicator. This means that the precautionary principle should be applied, i.e. the clinician should err on the side of treating or preventing pain, as the cost of unnecessary treatment is relatively less severe than the cost of failing to manage animals that are suffering.

Barriers to Treatment

A survey by Huxley and Whay (2006) examined the reasons why practitioners tended to under-use analgesia in cattle. Over 90% of respondents to the survey considered that cattle benefited from analgesics as part of their treatment and that they recovered faster if they were administered; however, two thirds of respondents considered that the cost of analgesia was a major issue to their clients. Whilst the financial constraints of the industry must always be considered, there are a number of reasons why they need not always preclude effective analgesia:

- Many analgesic protocols (such as local anaesthetic techniques) are inexpensive to perform. Local anaesthetic drugs are economical and volumes required are generally low. Time spent in performing these techniques is also usually low, and will decrease as the experience of the clinician grows.
- Financial benefits are often an unexpected outcome of analgesic treatment. Increases in parameters such as growth rate after calf disbudding (Faulkner and Weary 2000) and milk yield after lameness cases (O'Callaghan-Lowe and others 2004) have been reported after analgesic therapy was combined with standard treatments. Whilst this increased performance may not cover the total cost of analgesic treatment, in the majority of situations it will partially offset the cost.
- Prices of the most commonly used non-steroidal anti-inflammatory drugs (NSAIDs) may fall in the future as more generic products become available.

Clinicians too often assume that farmers are unwilling to carry costs associated with improvements to the welfare of their animals. In the case of many farm animal owners (especially “hobby” farmers or owners of small herds), the client may be more prepared to pay than the clinician realises. A recent survey of commercial UK cattle farmers (with over 1,000 respondents) has demonstrated that for the majority of owners the cost of analgesics remains a significant issue; however this was not true for all respondents. When asked to state how much they would be prepared to pay for analgesics during and following the treatment of a range of conditions and procedures, the answers varied considerably. For all 13 conditions considered, a small minority of respondents stated they would consider between £35 and £50 (the highest bracket) an acceptable cost for analgesic treatment, but a more significant number were prepared to meet a lower cost. For example, when considering surgical castration of calves, 32% of respondents stated they would pay between £5 and £10 and eight percent stated £11 or more. When considering caesarean section surgery, 28% of respondents stated they would pay £11 to £20, 13% stated £21 to £35 and 6% stated £36 to £50 and when considering disbudding, 21% stated they would pay £5 to £10 and 4% stated £11 or more. This work suggests that for some owners cost is not the issue practitioners may initially believe and therefore it is important to offer a variety of costed analgesic treatment protocols for painful procedures and conditions.

One of the most noteworthy findings in the practitioner survey (Huxley and Whay 2006), was that respondents who did not use any analgesic agents during treatment estimated significantly lower pain scores for the condition or procedure in question (Table 1). This suggests that one of the key motivators for analgesic usage is the attending clinician's own perceptions of the patient's suffering. Therefore, one of the barriers for the provision of appropriate analgesia in cattle is, in some cases, an unwillingness or inability to consider or identify the level of pain cattle are suffering.

Misconceptions about Analgesia and Cattle

A number of common misconceptions also emerged from the survey. These are summarised and discussed below:

- **Age of the animal:** Young animals are often assumed to feel less pain than adults. A good example of this is the lack of analgesia used in castrating calves and lambs using rubber ring techniques. There is no evidence to show that young animals perceive pain to a lesser extent than adults. In the authors' opinion, young animals should be considered in exactly the same manner as adult animals.

- **Pain restricts movement which may be potentially damaging to the animal's condition:** If movement is likely to be damaging to an animal's condition appropriate analgesia should be provided and movement should be restricted by penning the animal tightly, rather than relying on the animal's suffering.
- **Analgesia may mask deterioration in the condition of the animal:** This view is likely to have stemmed from received wisdom in equine practice, where it has been considered that use of potent anti-endotoxic drugs such as flunixin may hamper monitoring of colic cases. Farm animals are rarely monitored on such a short-term basis, and other clinical signs can be used in these species to monitor progression of a disease.
- **Corticosteroids are effective analgesic agents:** Although corticosteroids are potent anti-inflammatories and act on the same pathway as NSAIDs, at therapeutic dose rates they are likely to produce less profound analgesia than NSAIDs.

Techniques for Alleviating Pain

An important concept in terms of alleviation of pain in cattle is that of pre-emptive versus reactive analgesia. Where pain is predictable (e.g. surgical procedures), it is preferable to provide pre-emptive analgesia. By ensuring that effective analgesia is in place before the onset of pain, phenomena such as wind-up, hyperalgesia and allodynia can be reduced or prevented. Obviously this is not always possible, but provision of analgesia as soon as possible after the onset of pain will minimise these effects. It should always be remembered that pre-emptive analgesia is likely to be more effective than reactive analgesia.

Multimodal analgesia is also an important concept. It is well recognised in human and companion animal medicine that the most effective analgesia is provided by using a combination of agents that act on different pathways, but this is an often-neglected strategy in relation to cattle, where it could frequently be gainfully employed (e.g. the use of an epidural containing local anaesthetic and xylazine, combined with systemic NSAID to provide analgesia for dystocia).

There are several routes that can be used to provide analgesia to cattle. Systemic treatment involves parenteral administration of systemically active analgesic agents, while local techniques such as epidural anaesthesia, local nerve blocks and intravenous regional anaesthesia provide analgesia to specific areas.

Systemic Analgesic Techniques

The main groups of analgesic drugs available for use in animals are NSAIDs, α_2-agonists and opioids. Licensing is a major issue in prescribing for food producing animals (see Box Figure 1), and this places a major restriction on the agents that can be used in cattle. A variety of NSAIDs are licensed, along with the α_2-agonist xylazine.

- **NSAIDs:** This class of drugs works by inhibition of inflammatory mediators (see Box Figure 2). They provide effective analgesia for mild to moderate pain, and are administered by a variety of routes (see Table 2). They also have anti-endotoxic effects, which provide major benefits in terms of morbidity and mortality in some disease states. Duration of activity is generally in the range 24-72 hours per dose. Some products are licensed for repeated administration (up to a maximum of five days of treatment), but have been used for longer periods with few reports of side-effects (although abomasal ulceration has been reported anecdotally).

- **α_2-agonists:** These agents work by activation of α_2-adrenoreceptors in the central and peripheral autonomic nervous system. These have a negative effect on sympathetic activity and release of noradrenaline, leading to sedation and analgesia. They can provide deep sedation and effective analgesia for moderate pain in cattle. As the sedative and analgesic effects of this class of drug go together, they are more useful during some types of surgery and are not used for provision of longer-term analgesia. Xylazine is the only licensed drug in this class.
- **Opioids:** Opioids are very potent analgesics, and are an important component of multimodal analgesia protocols in other species. However, under current legislation, no opioid agents are available for use in cattle.

Regional and Local Techniques

The main techniques for providing local analgesia are epidural analgesia, intravenous regional anaesthesia and nerve blocks.

- **Epidural analgesia:** This technique involves injection of analgesic agents into the epidural space, to provide desensitisation of nerves leaving the spinal cord. Although outside the scope of this article, a full description of the technique, which is quick and straightforward to perform in cattle, is provided by Holden (1998).

Low-volume (4-6ml of injectate for an adult bovine) epidural anaesthesia is most commonly performed, providing anaesthesia of the genital tract, rectum and perinaeal area and abolition of tenesmus. High volume (up to 100ml per adult bovine) techniques are also described, and may be used to provide anaesthesia for the entire abdomen. High volume techniques will involve loss of motor control to the hindlimbs, so will result in the patient becoming recumbent. Local anaesthetic is the most commonly used agent, but xylazine has also been extensively used. Xylazine provides a longer duration of action compared to local anaesthetic alone, and the two agents are often used in combination (Grubb and others 2002). A number of dosage regimes are described, including a xylazine dosage of 0.05mg/kg (1.25ml of 2% xylazine per 500kg) with the remainder of the injectate made up of local anaesthetic. This use of xylazine is not licensed.

- **Intravenous regional anaesthesia (IVRA):** This is another quick and easy technique (see Box Figure 3 for description). It provides desensitisation of the limb distal to the tourniquet, and so is very useful for painful procedures in the foot (both foot surgery and treatment of severe claw horn lesions). It should be remembered that the effects of the IVRA will quickly wear off once the tourniquet is released, and no ongoing analgesia is provided. It is therefore usually advisable to use NSAIDs in combination, to provide a longer duration of effective pain relief. This use of local anaesthetic is off-licence.

- **Local nerve blocks**: A number of nerve block techniques are described in cattle. Again, specific description of the techniques is outside the scope of this article, but have been described previously (Edwards 2001). These techniques are summarised in Table 3. Local anaesthetics (procaine is now the only licensed product in food producing animals) are the most commonly used agents, providing 30-90 minutes of effective anaesthesia. Local anaesthetic/xylazine combinations may also be used for these techniques, and are thought to provide an extended duration of analgesia. Again, this is off-licence, and there is little research evaluating the combination. It has been suggested that α_2-agonists are unlikely to have local effects and that any clinical differences seen may be due to systemic absorption. With this in mind, the possibility of sedation as a side-effect should be considered.

Ring blocks are a method for blocking distal appendages (e.g. teats and distal limbs). Local anaesthetic is introduced at various points and depths around the circumference of the appendage in order to block nerve supply distal to the location of injection. These require multiple injections, and are generally less effective. In addition, as procaine with adrenaline is the only licensed product, the potential vasoconstrictive effect of infiltrating adrenaline around a small appendage (e.g. a teat) should also be considered, as necrosis may result. Infiltration of local anaesthetic around the area to be desensitised is also useful in some situations.

Suggested Standard Operating Procedures for Management of Pain in Specific Situations

Standing Flank Laporotomy in Adult Cattle

- Systemic NSAID before the start of surgery.
- Systemic xylazine could be used, but extreme care would be needed with dose to ensure the animal does not become recumbent. May be useful to provide extra

short-term analgesia if a very painful procedure is anticipated. May be necessary in very fractious patients.

- Paravertebral nerve blocks to provide effective anaesthesia of the flank area using procaine.
- Epidural anaesthesia may be used in the case of a caesarean section, to abolish tenesmus that may hinder surgery.

Castration and Disbudding of Calves

- Cornual nerve block using local anaesthetic (possibly in combination with low dose perineural xylazine in some cases - although this use of xylazine is off-licence, the consequences of which would have to be explained to the owner).
- Local infiltration of local anaesthetic in the skin of the distal scrotum (surgical castration) and over the neck of the scrotum to provide analgesia to the spermatic cord (surgical and burdizzo castration). Injection of local anaesthetic into the testes themselves may or may not be used.
- Where economically acceptable, pre-emptive use of NSAIDs is a desirable addition to the protocol. Several researchers have found welfare benefits as a result (Earley and Crowe 2002; Ting and others 2003). Clinicians too often fail to offer this option to clients, who may well be happy to the relatively small cost of extended analgesia.

Foot surgery/ treatment of severe claw horn lesions e.g. severe sole ulcers

- Systemic NSAID before start of treatment.

- IVRA for short-term anaesthesia of the foot.

Other potentially painful conditions where NSAID use should be considered

- Joint ill and navel ill in calves: Septic arthritis in particular is considered to be an extremely painful condition in humans and companion animals, but analgesia is too often neglected in cattle.
- Mastitis: NSAIDs should be considered for use in all cases of mastitis involving udder or systemic signs (as opposed to mastitis where signs are restricted to milk changes) (Milne and others 2003).
- Lameness: In addition to foot surgery and radical treatment of severe claw horn lesions, benefits are also seen as a result of NSAID use in less severe lameness cases (O'Callaghan-Lowe and others 2004).
- Dystocia: NSAID use is relatively common following dystocia. It is worth considering providing analgesia to the calf as well as the dam.
- Uveitis and keratoconjunctivitis: These are both relatively common ocular conditions in cattle (“silage eye” and “New Forest eye”), and the underlying pathology (uveitis and corneal ulceration respectively) is considered to produce severe pain in humans and companion animals. As well as providing analgesia, NSAIDs may increase speed of response to treatment by decreasing inflammation in cases of uveitis.

Conclusions

Despite an increase in research into and awareness of pain in cattle over the last fifteen years, management of painful conditions in cattle is still too rarely considered in practice. This article provides information on the methods by which analgesia may be provided, as well as suggesting standard protocols for pain management in specific conditions.

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Box figure 1 – place near reference in main text (line 193)

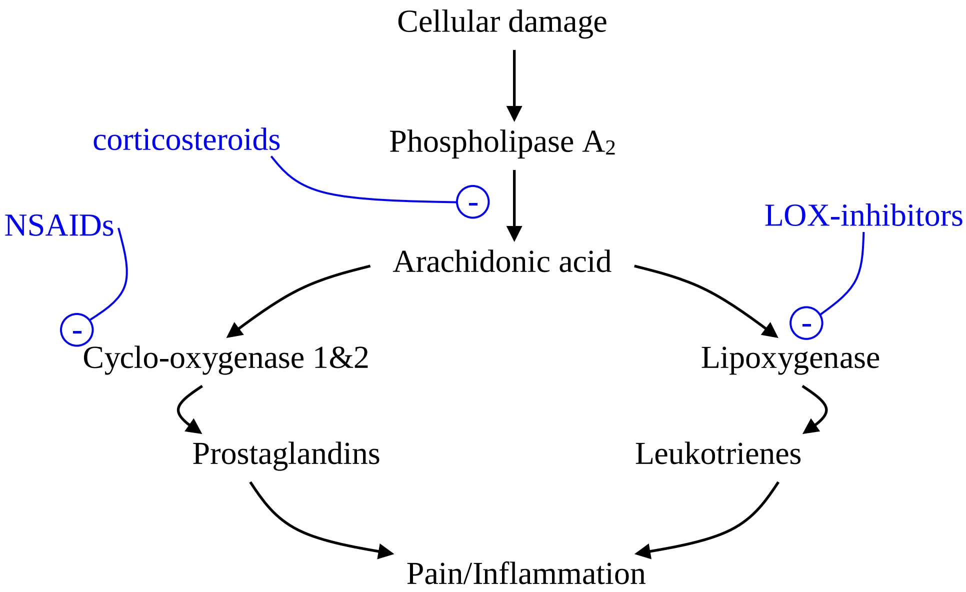
Licensing of Veterinary Medicines

Licensing issues have a major effect on product choices in farm animal medicine. The Veterinary Medicines Regulations (2005) provide for administration of products outside the terms of the product's marketing authorisation under the prescribing "cascade". However, they state that "any pharmacologically active substances included in a medicinal product administered to a food-producing animal under the cascade must be listed in Annex I, II or III to Council Regulation (EEC) No. 2377/90." Annex I lists substances for which a definitive maximum residue limit (MRL) has been established. These are generally found in products which have an authorisation for use in food producing animals. Annex II lists substances which, following initial evaluation by the European Medicines Agency (EMEA), were deemed to pose sufficiently little risk to public health not to necessitate the determination of a MRL. Annex III lists substances which are undergoing MRL determination at the current time and have been given provisional MRLs as there are considered to be no outstanding ongoing safety issues.

In practical terms, this means that only pharmacologically active substances listed in Annexes I, II and III can be used in veterinary medicinal products for use in food production animals. The only potentially useful compounds listed in Annex II for food producing animals are ketamine and thiopentone (butorphanol, isoflurane and lidocaine are also listed but the listing is restricted to equidae only). This restricts drugs for use as analgesics to a variety of NSAIDs, procaine and xylazine (with ketamine and thiopentone the only options for general anaesthesia). Further and frequently updated information is available from http://www.emea.europa.eu/index/indexv1.htm.

Box figure 2 – place near reference in text (line 197)

Mode of Action of NSAIDs



A simplified mode of action for NSAIDs is given in the diagram above. Inhibition of cyclo-oxygenase (COX) enzymes decreases prostaglandin synthesis, thereby decreasing pain and inflammation. As well as mediating inflammation, some COX-1 enzymes have alternative “housekeeping” functions and are induced in the absence of cellular damage. Their roles include gastroprotection and maintenance of renal bloodflow. Inhibition of these enzymes can bring about the side-effects of NSAIDs, notably gastric ulceration and renal disease. These are not well recognised in farm animals, although there have been anecdotal reports of abomasal ulceration in calves after treatment with NSAIDs. One possible reason for the apparent lack of side effects is the short term nature of the vast majority of NSAID use in these species. NSAIDs that preferentially inhibit COX-2 enzymes to a greater degree than COX-1 may be less likely to produce side effects.

It is clear from the diagram that production of leukotrienes by induction of the enzyme lipoxygenase (LOX) is also an important inflammatory pathway. LOX inhibitors are available in human and companion animal medicine (e.g. tepoxalin), but as yet none are licensed for farm animals. However, there is evidence that tolfenamic acid has some inhibitory activity against LOX. Some NSAIDs are also though to have a direct inhibitory action on leukotrienes.

A third COX enzyme has been identified (COX-3). Inhibition of this enzyme is thought to be responsible for some of the activity of paracetamol (a NSAID-like agent which is considered to have relatively little COX-1 and -2 inhibition). While paracetamol is not clinically relevant to cattle, the activity of carprofen may also be partly due to COX-3 inhibition. Other factors, such as how effectively the agent crosses the blood-brain barrier, may also be significant in determining the effectiveness of a NSAID.

Box figure 3 – place near reference in text (line 235)

Intravenous Regional Anaesthesia for the Bovine Hindlimb: A Standard Operating Procedure

IVRA is a quick and simple technique to perform, and is underused in the treatment of lame cows.

Equipment required:

- Appropriate handling facilities (i.e. foot trimming crush)
- Clippers/scissors
- Chlorhexidine surgical scrub
- Surgical spirit
- Tourniquet (a bicycle tyre inner tube is a good choice)
- 20-30ml local anaesthetic in syringe (procaine is now the only legal option), depending on the size of the animal
- 18 gauge, 1.5 inch needle

Procedure:

- The animal is restrained in the crush, with the affected limb raised. The procedure is easier to perform if the limb is not tied to the upright of the crush (as this will get in the way of the injection site).
- The dorsolateral aspect of the metatarsus is clipped and surgically prepared.

- A tourniquet is applied to the limb, either below or above the hock. If the tourniquet is above the hock, rolls of bandage or similar may be required to fill the spaces either side of the gastrocnemius tendon. For this reason, the authors prefer to apply it below the hock. The tourniquet must be applied sufficiently tightly and secured.
- The lateral saphenous vein is palpated running directly up the dorsolateral aspect of the metatarsus. The needle is then placed in the vein (directed distally), with the entire length of the needle in the lumen of the vessel. A good needle placement increases stability of vascular access while the local anaesthetic is injected.
- Blood is allowed to drain through the needle until the pressure drops so that blood is dripping rather than running out of the hub.
- The syringe is connected and the local anaesthetic slowly injected.
- After five to ten minutes, desensitisation of the foot can be checked by pricking the skin of the interdigital space with a sterile needle.
- When the procedure is finished, the tourniquet should be removed gradually (to prevent the theoretical possibility of a bolus of local anaesthetic entering the circulation). This is more important if the procedure has been very short.

The procedure is easily adapted to use in a forelimb (although restraint can be more difficult in this situation, and it is worth considering casting the animal).

Box figure (no reference) – place anywhere in second half of text (preferably around "Techniques for alleviating pain" section, lines 168-264)

General Anaesthesia in Farm Animals

In many respects, general anaesthesia can be thought of as the "gold standard" in terms of pain management. However, it is important to remember that induction of and recovery from general anaesthesia are stressful processes and that general anaesthesia only provides pain relief for the duration of the anaesthetic. Some agents have very poor analgesic properties, and multimodal pain relief should be employed.

Detailed descriptions of anaesthetic techniques are outside the scope of this article, but general anaesthesia (either in the field or in a hospital setting) is a useful procedure, particularly in young animals (the weight of the gastrointestinal tract makes it more dangerous in adults). Licensing restrictions affect which products may be used, but anaesthesia may be induced using a xylazine and ketamine combination, and maintained with incremental doses of ketamine. A side-benefit of the use of ketamine is that, as an NMDA antagonist, it is thought to interrupt central pain amplification processes (wind-up). Endotracheal intubation (with or without oxygen supplementation) is recommended in all cases, even though volatile agents cannot be used for maintenance. Obviously, this is only suitable for shorter procedures. Isoflurane could be used for maintenance to make longer procedures practicable, but under current licensing rules this is not allowed.

Box figure (no reference) – place anywhere in first half of text (preferably near “Barriers to treatment” and “Misconceptions about analgesia and cattle” sections, lines 97-167)

Legal Aspects of Analgesia

The major legislation relevant specifically to this area is summarised below:

- **Protection of Animals (Anaesthetics) Act 1954** (as amended) states that anaesthetic must be used for “any operation, with or without the use of instruments, which involves interference with the sensitive tissues or the bone structure of an animal” with the exception of injection or extraction by means of a hollow needle. Some specific exclusions apply (e.g. life-saving or emergency first aid treatment or minor procedures customarily performed without anaesthetic). With regard to routine husbandry procedures in calves, anaesthetic must be used when:
    - Castrating calves over two months of age
    - Disbudding or dehorning cattle of any age (with the exception of chemical cautery, which is only permitted during the first week of life)
    - Removing supernumerary teats from calves of over three months of age
- More generally, the **Agriculture (Miscellaneous Provisions) Act 1968** states that it is an offence to cause unnecessary pain or unnecessary distress to any livestock on agricultural land.
- Similarly, the **Welfare of Farmed Animals (England) Regulations 2000** state that owners and keepers of animals shall take all reasonable steps:

    - To ensure the welfare of the animals under their care; and
    - To ensure that the animals are not caused any unnecessary pain, suffering or injury.

- The most relevant issues raised by the new **Animal Welfare Act 2006** are the requirement for the person responsible for an individual animal to comply with "good practice" in order satisfy the animals need to be "protected from pain", and the concept that duty of care passes from the owner/keeper to the veterinary surgeon during treatment of the animal.

Box figure (no reference) – place anywhere in second half of text, preferably near to "Techniques for alleviating pain" section (lines 168-264)

Provision of Long Term Analgesia to Farm Animals

Providing long-term pain management to farm animals with chronically painful conditions is currently difficult. This is largely due to licensing restrictions and cost. In the past, oral phenylbutazone has been used for this purpose, but use of phenylbutazone in food producing species is now illegal.

The alternative approach is the use of repeated doses of injectable NSAID. This is off-licence beyond five days, although it could be justified under the cascade system (as authorised NSAIDs all have established MRL values, the standard withdrawal periods of seven days milk withdrawal and 28 days meat withdrawal would apply). The safety of long-term NSAID treatment in farm animals has not been extensively researched, although there were anecdotal reports of long term phenylbutazone use being well tolerated. The major barrier to long-term use of parenteral NSAID is cost: ketoprofen given daily would cost approximately £1.20 - £1.70/100kg/day, while meloxicam given every three days would cost £0.57/100kg/day (at list price). This level of expenditure may only be justified in a limited number of cases, so use of NSAIDs is usually restricted to coverage of episodes of acute pain. Euthanasia should always be seriously considered in cases where an animal is likely to experience long-term pain.

Table 1 – place near reference in text (line 141)

Caption: A recent survey of UK cattle practitioners with over 500 respondents asked clinicians to judge the severity of pain associated with a range of procedure and conditions on a ten point scale (1 = No pain at all; 10 = The worst pain imaginable). The results are outlined in the table below. The median pain score is the score assigned by the middle clinician if all the scores are arranged in ascending order and the modal pain score was the most frequently given answer.

		Median Pain Score	Range - Min	Range - Max	Modal Pain Score
Adult Cattle Procedures	Treatment of a sole ulcer	6	1	10	7
	Claw amputation	10	2	10	10
	Caesarean section	9	1	10	10
	Dystocia[1]	7	2	10	8
	De-horning[2]	8	2	10	10
	Debriding a digital dermatitis lesion	6	1	10	5
	LDA surgery	9	2	10	10
Adult Cattle Conditions	Uveitis	6	1	10	7
	Fracture of tuber coxae	7	2	10	8
	LDA	3	1	10	3
	Digital dermatitis	6	2	10	5
	Acute Metritis	4	1	10	3
	Swollen hock	5	1	10	5
	Hock with hair loss	3	1	10	2
	Acute toxic *Escherichia coli* mastitis	7	1	10	7
	Mastitis (clots in milk only)	3	1	10	2
	Neck calluses	2	1	7	2

	White line disease with Sub-sole abscess	7	1	10	7
Calf Procedures	Calf castration (Surgical)	6	2	10	5
	Calf castration (Rubber ring)	6	1	10	5
	Calf castration (Burdizzo)	7	2	10	8
	Umbilical hernia surgery	8	2	10	10
	Disbudding	7	2	10	8
Calf Conditions	Distal limb fracture	8	2	10	8
	Following dystocia[1]	4	1	10	3
	Umbilical abscess	5	1	10	4
	Joint ill	7	1	10	8
	Pneumonia	6	1	10	5

Footnote: Respondents were asked to estimate the severity of pain assuming *NO* analgesic drugs were administered

[1]Fetal-maternal disproportion requiring traction alone

[2]Horns >8cm/3”

Reproduced from Huxley and Whay (2006).

Place near to reference in text (line 198)

Table 2: Costs of commonly used drugs and techniques.

	Products	Licensed route(s)	Milk/meat withdrawal	Dose rate	Cost /ml	Cost /100kg	Licensed indications
Systemic							
NSAIDs							
Carprofen	Rimadyl™ (Pfizer)	i/v, s/c	n-l/21d	1ml/35kg	121p	£3.44[2]	Respiratory disease
Flunixin	Binixin™ (Bayer) Cronyxin™ (Bimeda) Finadyne™ (Schering Plough) Meflosyl 5% (Fort Dodge)	i/v	12-36h/ 5-8d	2ml/45kg	12- 42p	51p – £1.86	Respiratory disease, mastitis
Ketoprofen	Comforion™ (Janssen) Ketofen™ (Merial)	i/v, i/m	0/1-4d	1ml/33kg	39- 61p	£1.18- £1.85	Parturient paresis, respiratory disease, mastitis, udder oedema[1]
Meloxicam	Metacam™ (Boehringer Ingelheim)	i/v, s/c	5d/15d	2.5ml/100kg	75p	£1.88[2]	Respiratory disease, mastitis, diarrhoea in youngstock
Tolfenamic acid	Tolfine™ (Vetoquinol)	i/v, s/c (s/c limited)	24h/3-7d	1ml/10kg or 1ml/20kg[3]	29p	£1.44 - £2.87	Mastitis, respiratory disease
α_2-agonists							
Xylazine[4]	Chanazine™ 2% (Chanelle) Rompun™ 2% (Bayer) Sedaxylan™ (CEVA) Virbaxyl™ 2% (Virbac) Xylacare™ 2% (Animalcare) Xylapan™ (Vetoquinol)	i/v (Sedaxylan only), i/m	0d-24h, some n-l / 1d – 14d	0.15 – 1.5ml /100kg	91p - £1.39	18p - £2.09	Sedation, muscle relaxation and analgesia. See data sheets for specific indications.
Local techniques							
Procaine	Willcain™ (Arnolds)		0/0	Depends on	3.5p/		

[1] Indications vary between the two licensed products.

[2] Meloxicam and carprofen may have longer durations of action than the other NSAIDs.

[3] Dose rate for tolfenamic acid varies with indication

[4] Xylazine should be used with caution in potentially pregnant animals – see data sheet for further information.

				technique:	ml		
				epidural[5] cornual paravertebral IVRA[5]		18p 35p £2.80 88p	

i/v = intravenous, i/m = intramuscular, s/c = subcutaneous
n-l = not licensed for use in lactating cattle

This is not a comprehensive list – it is restricted to those products listed in the NOAH data sheets compendium. Other NSAIDs for animal use are available. Drug costs are given at list price. Costs and dose rates are intended as guides only – the product datasheet should always be consulted before administering a medicine. The authors accept no liability for costs arising due to errors in this material.

[5] Use of procaine by this route is off-licence.

Place near to reference in text (line 245).

Table 3: Nerve blocks commonly used in cattle.

Nerve block	**Area of analgesia**	**Notes**
Paravertebral	Flank	Quick and simple way to provide anaesthesia for flank surgery
Cornual	Horn and surrounding skin in calves	Less effective in adults
Retrobulbar	Eye and adnexa	May result in damage to adnexal structures, usually reserved for enucleation
Peterson	Eye and adnexa except eyelids	Less destructive than retrobulbar, need to anaesthetise eyelids separately for enucleation.
Auriculopalpebral	Eyelids (*motor function only*)	Provides paralysis but not desensitisation of eyelids
Common peroneal and tibial	Hindlimb distal to tarsus	A good alternative to IVRA, although technically more difficult.