Reducing Pain During Painful Procedures

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Take Home Messages

- Cattle feel pain and pain management should be considered when performing painful procedures. As a rule of thumb, if you expect a procedure would cause you pain, it will likely cause pain in your cattle.
- There are different classes of pain medications including local anesthetics, non-steroidal anti-inflammatory drugs (NSAIDs) and sedatives. These drugs act in different locations of the pain pathway.
- Pain management for disbudding in calves is economical, practical and significantly reduces pain. A local anesthetic block with lidocaine and a systemic NSAID (ketoprofen or flunixin meglumine) is recommended when disbudding calves.
- When considering pain management, there should be a balance between economics, practicality and animal welfare.
- The dairy industry needs to be proactive in initiating changes in pain management practices, as agricultural practices are coming under increasing scrutiny from the public. Public perception of your industry and practices will impact demand for the products you produce.
- Discuss practical pain management options for your dairy operation with your veterinarian.

Physiology of Pain

What is Pain?

Pain is defined as an unpleasant sensory or emotional experience associated with actual or potential tissue damage. Pain can be physiologic, such as pain experienced by a cow during calving, or pathologic, such as pain resulting from a surgical procedure. Pain is also classified as acute or chronic. Acute pain is pain of short duration that doesn't last any longer than healing of an injury. Chronic pain is pain of long duration that can last longer than the normal healing process. Pain associated with surgical procedures is generally acute pain that is felt during a procedure.

Pathophysiology of Pain

Pain occurs through stimulation of the nervous system. The nervous system is composed of the central nervous system and the peripheral nervous system. The central nervous system includes the brain, brainstem and spinal cord. The peripheral nervous system is composed of all of the nerves that extend from the brain and spinal cord to various parts of the body.

The basic unit that makes up the nervous system is the neuron, or nerve. The central nervous system contains more than 100 billion neurons. Neurons can be classified as sensory neurons, motor neurons or interneurons. Sensory neurons take information from nerve endings in the skin, muscles and other organs to the brain. Motor neurons transmit information away from the spinal cord to the muscles to allow us to react to a stimulus. Interneurons are nerves that make interconnections within the central nervous system to help regulate the transfer of information from sensory nerves to motor nerves or other neurons in the brain and spinal cord.

A reflex is an example of how nerves work. If you touch a hot surface, you will automatically pull your hand away before you feel any pain from the stimulus. Nerve endings in the skin (sensory receptors) are triggered by thermal (hot or cold), mechanical, or chemical stimuli, such as a hot pot on the stove. The stimulus activates the sensory neuron to send a signal to the spinal cord where it connects to a motor neuron. When stimulated, the motor neuron will send a signal to the muscles in the arm to move the hand away from the stimulus. No information has to travel to the brain in order for a reflex reaction to occur. This example illustrates the concept of nociception. Nociception is the activation of nerve endings by a painful stimulus. Nociception is not always the same as pain. In order for an animal to feel pain, nerve signals must travel from the sensory neuron up to the appropriate part of the brain. It is the brain that recognizes pain. Figure 1 depicts the basic pathophysiology of pain.

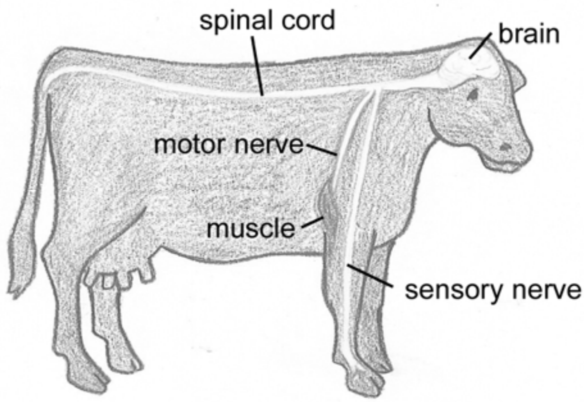

Figure 1: A painful stimulus is perceived by nerve endings and is transmitted to the spinal cord through sensory nerve fibers. Once at the level of the spinal cord, information is modulated by interconnecting neurons and relayed to the brain where the painful stimulus is perceived.

How Do Neurons Transmit Information?

Electric potentials exist across the membranes of all cell types. Nerve and muscle cells are able to transmit electric impulses, also known as action potentials. Action potentials are how neurons transmit information from one end of the nerve cell to the other. For example, the nerve endings of a sensory neuron trigger an action potential when exposed to a thermal, chemical or mechanical stimulus. Action potentials occur when the electric current across a neuron changes rapidly. These changes in electric current occur through the opening and closing of positive ion (sodium and potassium) channels. One of these channels is the voltage gated sodium channel and will be discussed later in this document.

Nerve cells communicate with one another through neurotransmitters. There are many different neurotransmitters in the brain and spinal cord. Neurotransmitters can be excitatory or inhibitory. Excitatory neurotransmitters cause an increase in transmission of information between neurons. Inhibitory neurons decrease the transfer of information. Some neurotransmitters increase the sensation of pain while others decrease pain.

▪ Do Cattle Feel Pain?

There has been much research over the past 30 years looking at whether animals feel pain. From a biological view, all mammals have a similar nervous system and similar pathways to experience pain. It is widely accepted that animals feel physical pain. Emotional pain has been much more difficult to assess.

Assessment of pain in cattle can be very difficult. Most research examines behavioural and physiological signs of pain. Behavioural signs of pain are abnormal behaviours associated with a painful event. Cattle are considered a prey species and are less likely to show signs of pain than other animals and people. It is a natural survival instinct for prey species to hide signs of pain and illness to avoid being targeted by predators. When evaluating pain, it is sometimes difficult to observe and interpret behavioral signs of pain. Some pain behaviours can be very subtle such as tail swishing after castration or ear flicking and head shaking after dehorning. Assessing behaviour can also be very subjective.

Physiologic signs of pain are responses of the body in response to a painful stimulus. When the brain perceives a painful stimulus, the sympathetic nervous system is activated and creates an adrenaline response, or adrenaline rush. Adrenaline causes increases in heart rate and blood pressure, and an increase in the stress hormone, cortisol. Heart rate, blood pressure and cortisol can be measured as objective indicators of pain. Other indirect measures of pain include production parameters such as feed consumption, milk production and weight gain.

Pain vs. Stress

One of the biggest difficulties in assessing pain in cattle is differentiating between pain and stress. Cattle can become stressed from handling and restraint, without any painful stimulus. Stress will also cause an adrenaline response with increases in heart rate and cortisol. How then, are pain and stress differentiated? Most research attempts to differentiate between pain and stress through the use of control groups. Control groups are groups of animals in a study that do not receive a painful stimulus. For example, in a castration study, a group of calves that undergo surgical castration will be compared with a group of calves who are handled and restrained in the same way but not castrated. Any difference in behavioural or physiologic measures of pain can then be interpreted as a result of the painful procedure rather than the stress of handling.

Recently, a chemical called Substance P has been evaluated as an indicator of pain in cattle undergoing castration (Coetzee 2008). Substance P is a neurotransmitter found in the brain and spinal cord that causes increased transmission of pain. Substance P has been found to be significantly higher in castrated calves when compared to controls. Cortisol levels in both groups of calves were the same. These results suggest that Substance P may be a specific measure for pain.

▪ The Use of Pain Medications

The development of pain medications, also known as analgesics, is a huge area in the pharmaceutical industry. Analgesics are widely used in people and in companion animals and new analgesics are continually being produced. Although the benefits of using analgesics in cattle for painful procedures have been widely studied it is a practice that has not necessarily been adopted by industry. The lack of use of pain medications by industry may result from economic concerns, a lack of information of the benefits of pain medications, and a slow transition from currently used routine practices.

How Do Pain Medications Work?

Pain medications can work in various ways depending on the drug being used. Pain occurs by the stimulation of a sensory nerve and transmission of the information to the brain where it is perceived as pain. Pain medications can decrease pain by acting at the site of injury, the sensory nerve, the spinal cord or in the brain (Figure 2).

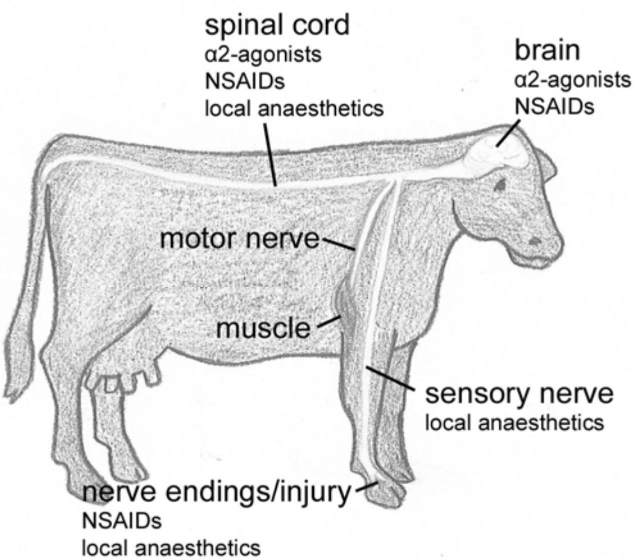

Figure 2: Pain medications act on different levels of the pain pathway.

Local Anesthetics

Local anesthetics act by blocking voltage gated sodium channels in the cell membrane of nerves. The opening of voltage gated sodium channels is responsible for the rapid change in electric current which results in an action potential. By blocking the action potential, a pain stimulus message cannot travel up the nerve and is therefore not perceived by the brain. Local anesthetics work locally at the site where they are administered and can block sensory neurons, motor neurons and neurons within the spinal cord. They are most commonly used to block sensory nerves around a surgical site, or as an epidural, to block nerves as they enter the spinal cord. There are different local anesthetics that vary in their potency, speed of onset and duration of action including lidocaine, procaine, mepivicaine and bupivicaine. Lidocaine is the most common local anesthetic used in cattle. Epinephrine can be added to lidocaine to cause constriction of blood vessels, which decreases the absorption of lidocaine and increases its duration of action.

Local anesthetics can cause severe side effects if given intravenously or in very high doses. Signs of toxicity include muscle twitching or convulsions followed by unconsciousness and respiratory arrest. Local anesthetics can also cause cardiac arrest. Doses exceeding 10 mg/kg of lidocaine 2% with epinephrine should not be used in cattle. This is equal to 25 ml in a 50 kg calf and 250 ml in a 500 kg cow. Lidocaine without epinephrine has a much lower safety margin (6 mg/kg). In Canada, the recommended milk withdrawal for lidocaine 2% with epinephrine is 96 hours and meat withdrawal is 5 days.

Non Steroidal Anti-Inflammatory Drugs

Non steroidal anti-inflammatory drugs (NSAIDs) relieve mild to moderately severe pain. During an injury, prostaglandins are produced in the body and are involved in the production of inflammation, swelling, pain and fever. There are many types of prostaglandins that function during both health and illness. Prostaglandins are produced by the enzyme,cyclooxygenase (COX). There are 3 different COX enzymes, COX-1, COX-2, and COX-3. NSAIDs act by inhibiting the COX enzymes and preventing prostaglandin synthesis. Some NSAIDs inhibit all COX enzymes while others are more selective. The analgesic effects of NSAIDs are exerted both locally, at a site of injury, and centrally, on the brain and spinal cord. NSAIDs decrease pain, swelling and fever and improve attitude and appetite. They are used in cattle for management of acute and chronic pain. There are two NSAIDs currently licensed for use in cattle in Canada (Table 1).

Table 1: Commonly used NSAIDs licensed for use in cattle in Canada.

Drug	Trade name	Dose	Route	Withdrawal (milk/meat)
Ketoprofen	Anafen	3.3 mg/kg 1.5 mL/50kg daily for 3 d	IV or IM	None/24 hr
Flunixin Meglumine	Banamine	2.2 mg/kg 2.2 mL/50 kg daily for 3 d	IV	36 hr/6 days

Newer NSAIDS. Newer generation NSAIDs are continually being produced and marketed. Meloxicam is a commonly used NSAID in dogs and cats as it has fewer adverse side effects compared to other NSAIDs. Meloxicam is approved for use in cattle in the UK. It is administered in the vein, under the skin, or in the muscle at a dose of 0.5 mg/kg. Withdrawal times for milk and meat are 5 days and 15 days, respectively.

Tolfenamic acid (Tolfine/Tolfedine CS) is licensed for cattle in Australia and some European countries at a dose of 2-4 mg/kg (1 ml per 10-20 kg) in the vein or in the muscle. It only needs to be administered every 48 hours. Withdrawal times for milk and meat are 12 hours and 10 days, respectively.

Once available in Canada, these NSAIDs will offer a wider selection of choices for pain management in dairy cattle.

Sedatives

A sedative is a drug that depresses the central nervous system causing drowsiness, relaxation and a reduction in anxiety. There are several different classes of sedatives however only two are commonly used in cattle; phenothiazines and α2-agonists. Acepromazine (Acevet) is a phenothiazine tranquilizer commonly used for sedation of cattle. It does not have any analgesic effects and should not be used for pain management. α2-agonists include xylazine, detomidine and romifidine. Xylazine (Rompun) is the most commonly used α2-agonist in cattle. α2-agonists produce sedation, pain relief and muscle relaxation. α2-agonists act on α2 receptors located throughout the body to produce the opposite response to the adrenaline response. Xylazine in cattle causes a decreased heart rate, blood pressure and rumen motility, sedation and analgesia. Pain relief occurs by activating α2 receptors in the brain and spinal cord, reducing the transmission of pain.

Xylazine is a veterinary use only drug, limiting its practicality for use by producers. It should be used cautiously in calves as they are sensitive to the cardiovascular effects.

▪ Practical Analgesic Techniques: What Are Your Options?

Local anesthetic techniques

Dehorning. Dehorning is a routine procedure in cattle. Disbudding refers to removal of the horn buds before they have attached to the skull, usually at around 2 months of age. The Canadian Veterinary Medical Association recommends dehorning be performed within the first week of life. Research has shown that disbudding without pain medication is painful (Stafford 2005). Calves disbudded using a hot iron show pain behaviours, including rearing, falling down, and head jerking and moving, indicative of severe pain and an elevated heart rate. It is believed that low grade pain associated with disbudding lasts for at least 24 hours.

Disbudding using a caustic paste is sometimes performed. Research has shown that caustic pastes are also painful when administered (Morrise et al 2005). Treated calves showed behavioural signs of pain for 4 hours following disbudding and increased cortisol levels.

Cornual nerve block. The cornual nerve block is the most commonly used local anesthetic technique for dehorning and disbudding cattle. Local anesthesia has been shown to eliminate pain behaviors before and immediately after disbudding. Calves struggle less and are easier to restrain.

To perform a cornual block, an 18-20 gauge, 2.5 cm needle is placed under the skin just below the ridge of the frontal bone, half way between the outer edge of the eye and the horn bud (Figure 3).

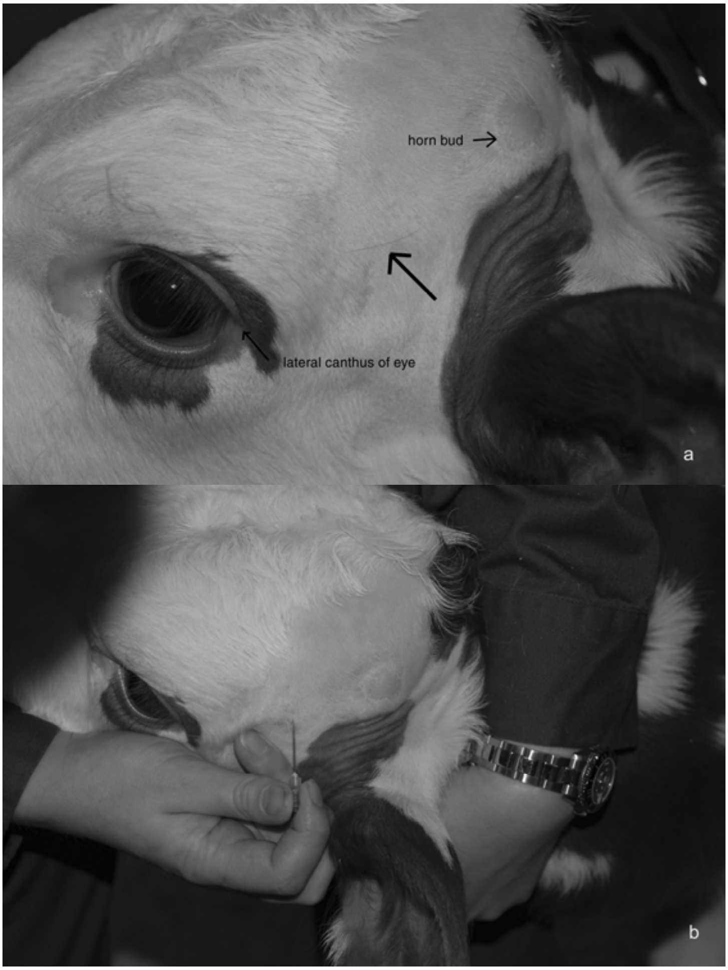

Figure 3: Site of administration of the cornual nerve block. a) Dark arrow demonstrates location for needle insertion just below the ridge of the frontal bone. b) Photo demonstrates restraint of the head and insertion of the needle.

Five milliliters of lidocaine 2% with epinephrine is injected 1 cm under the skin. This block must be performed on the right and left sides of the head to anaesthetize both horn buds. Preliminary results from a current study showed that the average onset time for anesthetic effect was 2.4 minutes and the block lasted an average of 5.3 hours. Seven out of eight of the blocks performed were effective (87.5%). Average cost and time to perform a cornual block is less than $2.00 and approximately 2 minutes, respectively.

Ring block. Some calves have an additional nerve supply to the back of the horn bud that is not affected by the cornual nerve block. Preliminary results from a current study showed that 100% of ring blocks were effective. Anesthetic onset took an average of 3.6 minutes and the blocks lasted an average of 2.7 hours.

To perform a ring block, 6 mL lidocaine with epinephrine is infiltrated underneath the skin surrounding the horn bud using an 18-20 gauge, 2.5 cm needle. Although reliable, calves struggled more during the administration of this block than the cornual block as the needle was inserted under the skin in 5-6 places.

NSAIDs and Local Anesthesia

Local anesthetics are effective in providing pain relief for acute surgical pain. Once the local anesthetic wears off, there is no long lasting pain relief. Studies have shown that once the local anesthetic effect has dissipated, cortisol levels increase. For this reason, it is currently recommended that both a local anesthetic and a NSAID be administered when disbudding calves. NSAIDs alone are not adequate pain relief for the surgical pain experienced during disbudding but they effectively decrease painful behaviours and cortisol levels after disbudding.

Xylazine and Local Anesthesia

The use of sedation alone decreases calf struggling but does not affect pain behaviours in response to disbudding, suggesting that sedation alone is not sufficient pain management (Grøndahl-Nielsen 1999). When sedation is combined with a local anesthetic, calves are easier to restrain and local anesthetic administration is facilitated. In Canada, xylazine is a veterinary-use only drug, limiting producer access to this sedative.

▪ Why Do We Need To Treat Pain?

This document has been designed to give you an understanding of how pain is experienced and to provide background information on available options for pain management. As a general rule of thumb, if you expect a procedure would cause you pain, it will likely cause pain in cattle. There are economic and time constraints affecting the use of some pain medications. Why then, is it important to consider the use of pain medications for painful procedures? When evaluating the need for pain medications, producers must find a balance of economically and practically feasible methods that address animal welfare, effects on production and industry concerns.

Welfare

The dairy industry needs to be proactive in initiating changes in pain management practices, as agricultural practices are coming under increasing scrutiny by the public. Animal welfare is an increasing area of public interest and concern. Research has shown that many routine procedures such as dehorning, castration and tail docking are painful. Dr. Temple Grandin has identified the most important dairy cattle welfare concerns to include lameness, dehorning and tail docking (AFAC website).

Adverse Effects on Production

The benefits of pain management on production parameters have been difficult to evaluate. The effect of pain medications in treating lameness and mastitis has shown that treated cows have an improved appetite and attitude. Cows with acute mastitis treated with ketoprofen have improved recovery rates (92.3%) than cows that do not receive any pain medication (70.7%) (Shpigel 2004). Benefits on return of milk production have been much more difficult to determine. There is a lack of research on the effects of pain management on production during surgical procedures such as correction of a displaced abomasum or caesarian section. Research in beef cattle undergoing band castration after weaning showed that castrated calves had a lower average daily gain than uncastrated controls for the first three weeks and decreased feed intake in week 4 after castration (personal communication, Dr. Karen Schwartzkopf-Genswein).

Export Concerns

The legislation pertaining to the use of analgesics in cattle differs between countries. Disbudding without anaesthetic and sedation is banned in Sweden. In the UK, calves less than one week of age may be dehorned with a caustic paste, but local anesthetics are required if other methods of dehorning are used. In North America, there is currently no legislation preventing cattle from being castrated, dehorned or tail docked without anesthetic. Traditionally, pain medications have not been widely used in cattle in Canada. A survey of dairy producers and veterinarians in Ontario in 2004 found that 22% of dairy producers use local anesthesia for disbudding calves (Misch 2007). The lack of use by producers was reportedly due to time, cost and an unawareness of available options. With increasing pressure from the World Trade Organization, food animal production is finding a global market. The future of milk and milk product trade and markets will likely include welfare requirements and standards. Developing practical and cost effective methods of pain management in dairy cattle is becoming increasingly important. A proactive approach to improving animal welfare with pain management techniques will help to address consumer and public concerns about animal welfare in the dairy industry.

▪ References

Coetzee JF, Lubbers BV, Toerber SE, et al. Plasma concentrations of substance P and cortisol in beef calves after castration or simulated castration. Am J Vet Res 2008;69:6:751-762.

Grøndahl-Nielsen C, Simonsen HB, Damkjer Lund J, Hesselholt M. Behavioural, endocrine, and cardiac responses in young calves undergoing dehorning without and with use of sedation and analgesia. Veterinary Journal 1999;158:14-20.

Misch LJ, Duffield TF, Millman ST, Lissemore KD. An investigation into the practices of dairy producers and veterinarians in dehorning dairy calves in Ontario. Canadian Veterinary Journal. 2007;48:1249-1254.

Morisse JP, Cotte Jp, Huonnic . Effect of dehorning on behavious and plasma cortisol responses in young calves. Applied Animal Behaviour Science. 1995; 43:239-247.

Shpigel NY, Chen R, Winkler M, Saran A, Ziv G, Longo F. Anti-inflammatory ketoprofen in the treatment of field cases of bovine mastitis. Res Vet Sci 1994;56:62-68.

Stafford KJ, Mellor DJ. Dehorning and disbudding distress and its alleviation in calves. Veterinary Journal 2005; 169:337-349.

AFAC website- http://www.afac.ab.ca/careinfo/handling/Grandinccontrol.htm

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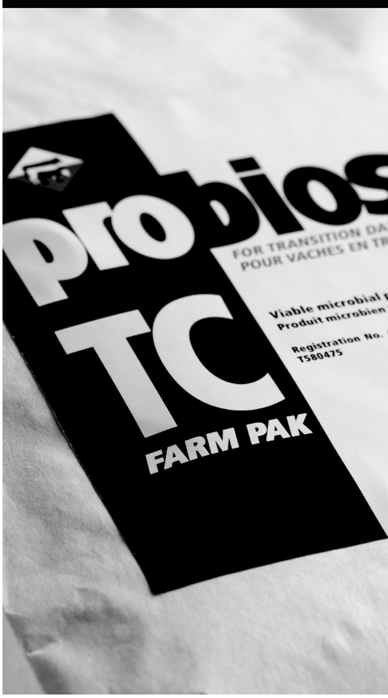

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