Achieving pain control for routine management procedures in North American beef cattle

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Introduction

Pain control for routine management procedures is considered one of the most important welfare priorities in livestock production today. This is particularly true at a time when public scrutiny regarding animal production and care is at a historical high (Bayvel, 2004). As such, it is imperative that the beef industry and in general the livestock industry be proactive regarding the adoption of practices that alleviate pain and improve overall animal welfare.

In this paper, pain will be defined as the unpleasant sensory or emotional experience associated with actual or potential tissue damage (International Association for the Study of Pain, 1979). Pain may further be defined as acute (occurring at the time of the procedure and in the first few days post procedure) or chronic (lasting weeks or months). It is widely accepted that certain management procedures cause pain to varying degrees. Although there is a plethora of published scientific studies dedicated to assessing pain as well as strategies aimed at reducing it, our knowledge of food animal pain, its assessment, and alleviation is still very limited (Flecknell, 2000).

It is important for the public to understand that even though there is significant will by the industry, veterinary profession, and academics working in this area to achieve pain control in food animals, it is not a simple task. As in human medicine, the ability to completely control pain is not possible for a multitude of reasons including finding effective drugs or drug combinations relevant for the type of pain control needed or the high cost of developing and registering a drug for market. The goal of this paper is to provide some understanding about the challenges that currently exist in providing pain control during and after certain management procedures have occurred.

Routine Management Procedures that Cause Pain: What Are They and Why Are They Needed?

In order to discuss the challenges of pain control it is important to give some examples of procedures that cause pain and why they are necessary. The most common procedures employed in North American beef cattle management that cause pain include castration, dehorning, and branding. Annual estimates for the number of animals undergoing these procedures in North America are difficult to obtain as they are not readily available or published. According to industry sources approximately 8 million cattle are castrated and 1.5 million cattle are dehorned annually (USDA, 2009; Canfax, 2011).

Castration

Castration is required to reduce aggression (towards other animals), improve handler safety, reduce sexual behavior (unwanted pregnancy), and improve meat quality (González et al., 2010; Coetzee, 2011). The most common methods of castration used include: 1) surgical castration, which is the removal of the testicles after making an incision into the scrotum; 2) band or ring castration, which involves constricting the blood...
supply to the testicles and scrotum; and 3) Burdizzo castration, which involves crushing of the spermatic cord and blood supply to the testicles. The ability to perform castration with certainty is important, because failure to do so will result in castration being performed at an older age (Stafford, 2007) when the pain and complications due to the procedure may be more severe. However, it is important to note that at this time little is known about the effects of animal age on pain. According to both the American and Canadian Veterinary Medical Associations (AVMA and CVMA, respectively), the castration methods listed above cause both acute and chronic pain (AVMA, 2006; CVMA, 2011). This conclusion is based on numerous studies providing strong scientific support based on behavioral and physiological indicators of pain measured as part of the assessment (Stafford and Mellor, 2005; Coetzee, 2011). Band castration in beef cattle has been shown to result in prolonged pain lasting up to four weeks after the procedure (González et al., 2010). High failure rates have been noted with the Burdizzo method making it least preferred by veterinarians (Stafford, 2007).

Disbudding and Dehorning

Disbudding refers to the destruction of the horn bud in young calves while dehorning refers to the removal of the horns after formation and attachment to the frontal bone (occurring around two months of age; AVMA, 2010). These procedures reduce the risk of injuries to human handlers and other animals and reduce carcass bruising (Stafford and Mellor, 2011). Disbudding is accomplished by destroying horn-producing cells using heat (hot-iron), chemicals (caustic paste), or by amputation. Dehorning can only be accomplished using physical methods which result in the amputation of the horn. Dehorning is recognized as a painful procedure by veterinarians (AVMA, 2010; CVMA, 2011). Numerous studies have documented that all horn removal methods cause pain (Sylvester et al., 2004; Schwartzkopf-Genswein et al., 2005; Stilwell et al., 2009, 2010; Stafford and Mellor, 2011). As a consequence North American veterinary organizations recommend dehorning is replaced through genetic selection whenever possible. Any animal undergoing disbudding or dehorning by amputation should receive, when possible, a local anesthetic and preferably post-operative pain control (Stafford and Mellor, 2011).

Branding

Although the practice of branding may seem reminiscent of the traditional management practices of the “old west,” it remains one of the few permanent methods of animal identification that is accepted as legal cattle ownership, primarily by lending institutions in North America today. It is also required by various governments to facilitate the export of cattle to a feed yard or for breeding purposes from Canada to the United States. It should be noted that a brand identifies ownership to a ranch or herd and is not useful for individual animal identification, which is important for lending security and disease control. Individual identification can be achieved through other relatively non-invasive practices such as ear tagging. Two methods of branding are used in beef cattle: 1) Hot-iron branding, which is done by heating irons to approximately 500 °C and applying them to the skin creating scar tissue void of hair; and 2) freeze branding, which is accomplished by cooling irons with either liquid nitrogen or a combination of dry ice and ethyl alcohol, which applied to the skin, results in the growth of white hair caused by the destruction of pigment producing cells within the hair follicle. Scientific study has shown that both methods cause pain and distress but that hot-iron branding appears to cause more acute pain than freeze branding (Lay et al., 1992a,b; Schwartzkopf-Genswein et al., 1997a,b,c; Schwartzkopf-Genswein and Stookley, 1997). At this time, there are no scientific studies published on assessing pain mitigation for branding in cattle.

Veterinarians and animal scientists agree the sooner both castration and dehorning is performed, preferably within the first week of life, the better the welfare of the animal. Research studies have shown that calves castrated or dehorned at a younger age experience lower declines in growth rate after the procedures to those in which the procedure was done at an older age (Goonewardene and Hand, 1991; Bretschneider, 2005; González et al., 2010). Likewise a study done on comparing wound healing of the frontal sinus after dehorning reported wounds healed more quickly (within four weeks) in animals dehorned at four and seven months of age but required more than six weeks to heal in calves dehorned at 19 or 30 months of age (Loxton et al., 1982). It should be noted that behavioral and physiological evidence of pain experienced at different animal ages is lacking at this time.

Policy and Legislation Regarding Routine Management Procedures

In North America, the use of pain control during or after castration, dehorning, and branding is voluntary and not subject to any legislative acts at this time. Instead, the North American industry prefers to follow a code of practice. These codes are voluntary and have been developed and endorsed together with veterinarians and animal scientists with the goal to promoting and recommending best management practices regarding cattle management in general and will be discussed briefly below. In Canada, the National Farm Animal Care Council (NFACC) in cooperation with the Canadian Cattlemen’s Association is responsible for producing and maintaining this code. The Canadian Codes are currently being revised and careful consideration is being given to updating sections of the code pertaining to these procedures. In the United States the National Cattlemen’s Beef Association (NCBA) is responsible for code development with the original code being revised and expanded in 2003. In contrast, several European countries including Sweden and the UK (DEFRA, 2003) have legislated the use of local anesthetics prior to dehorning and castration and the age at which these procedures can be done. Branding on the other hand is banned as a method of livestock identification in some European countries including Norway and the UK (DEFRA, 2003). The large inter-country variation in policy and legislation regarding these practices is a concern. This is due to the increasing pressure that the World Trade Organization may place on standardizing animal welfare requirements and those countries in noncompliance may suffer reduced opportunities for food product marketing and trade (Thiermann and Babcock, 2005).

Challenges in Achieving Pain Control

Pain control in livestock typically refers to the use of pain mitigating drugs known as analgesics and anesthetics. Analgesics reduce pain in the patient; however, they do not take sensation away (i.e., numbness). An example of analgesia is the use of ibuprofen for a headache. Anesthetics, on the other hand, cause lack of sensation (numbness), which results in lack of pain. Therefore, analgesia usually accompanies anesthesia. An
example of anesthesia is what results from the injection a dentist admin-
isters for filling a tooth.

Even though analgesics are widely available and used for humans and companion animal pain, their availability and thus use in food producing animals still remains low (Navarre, 2006). Recent surveys regarding pain control in food and companion animals show marked differences in usage by animal type and country (Figure 1). The potential reasons for low industry adoption of pain control in food animals are covered separately in the following sections.

**Accurate Assessment of Pain**

An integral part of mitigating pain is first being able to document that it occurs and then documenting if the pain mitigation strategies we employ actually eliminate it. This is a very complex and tedious process that relies upon our ability to accurately measure pain. Pain assessment in animals is problematic by the very fact that animals cannot tell us what they feel. In addition, pain responses vary greatly between individuals, and the severity of clinical signs of pain doesn’t always match the severity of a lesion (Navarre, 2006). Consequently, scientists can only assess the pain an animal may perceive by measuring behavioral or physiological responses caused by a particular procedure (Figure 2). Both acute and chronic pain assessment in cattle may be even more problematic because they are a prey species that evolved to mask signs of pain so that predators would be less likely to use overt cues (such as excessive vocalizing and struggling) to target and kill injured or weak individuals within a herd. It should be noted that the “masking” of pain by cattle is merely a scientific theory at this time.

Behavioral assessments of pain have been used by the veterinary and animal science professions since their inception. These assessments typically involve visual appraisals of an animal’s posture, movement, vigor, and motivation to eat and drink (Morton and Griffiths, 1985; Weary et al., 2009). Although skilled animal husbandry workers use these visual assessments to identify animals requiring medical attention, visual assessments are subjective in nature and caution must be used in interpreting them (Weary et al., 2009). A common measure of pain is the decline in the frequency or magnitude of certain behaviors (Weary et al., 2006). Studies have documented reduced activity (i.e., reduce step length; González et al., 2010) and reactivity (latency to withdraw from a handler; Thornton and Waterman-Pearson, 1999) in animals experiencing pain. Based on this information, it is reasonable to predict that movements such as walking and running after surgical castration, for example, may increase pain resulting in the decline of such movement (Weary et al., 2006). A decline in walking may also result in reduced feed and water intake, which are common and accepted behavioural indicators of pain. As a consequence scientists are using current technology, including digital video recording, radio frequency identification, image analysis (González et al., 2010), accelerometers, strain gauge and load cell instrumentation (Schwartzkopf-Genswein et al., 1997b), and pedometers (Coetzee, 2011). These technologies allow for the objective quantification of livestock behavior previously unattainable by visual assessment alone. Electronic quantification of individual animal responses to pain, including stimuli specific or daily movements and individual feed and water intake, have been used successfully to identify the onset, magnitude, and duration of pain associated with various routine management procedures used in cattle (González et al., 2010).

The use of physiological parameters has long been an accepted method of assessing animal pain by scientists. The most common of these measures include: the stress hormone cortisol, heart and respiration rate, changes in body temperature, and more recently, brain activity and neuro-endocrine biomarkers of pain such as a compound known as substance P (Coetzee, 2011). These measures are useful because of their direct relationship to pain and stress. Pain causes the animals stress response system to mount an effort to maintain a stable internal environment, which is accomplished, for example, by increasing heart and respiration rate and body temperature, which prepares the animal for what is known as the “flight of flight” response (Ewing, Lay and von Borell, 1999). Technology is also an integral part of measuring the physiological indicators mentioned above and includes electroencephalography (EEG), thermography and heart rate monitors (Coetzee, 2011). It should be noted that pain researchers also need to interpret physiological data carefully. For example, just handling the animals can elevate some of these measures (i.e., heart rate and cortisol; Broom and Johnson, 1993). Other factors such as normal daily fluctuations (as with body temperature and hormone secretion), animal genetics, and prior experience to handling can affect physiology to the same extent as the procedure being assessed (Broom and Johnson, 1993). Emphasis should be on the use of a combination of non-invasive methods.

Substantial research is still required to determine the relationship between behavioral and physiological indicators of pain. It should be noted that appropriate behavioral and physiological measures will differ depending on whether you are trying to assess acute or chronic pain. The continued development and validation of novel, quantifiable methods of pain assessment using behavior and physiology is essential to further our understanding for pain identification and control purposes.

**Availability of Drugs that Control Pain**

Several classes of pain controlling drugs have been developed. They include local anesthetics, nonsteroidal anti-inflammatory drugs (NSAIDs), α2-agonists, and opioids (Coetzee, 2011; Fierheller, 2009; Navarre, 2006). Common pain control drugs, their classifications, and dosages for use in food animals in North American livestock are presented in Table 1. Although many of these drugs are used routinely in humans, companion animals, and horses, their use is limited in food animals. Table 1 indicates that the drugs listed are for use in cattle; however, they are not necessarily labeled for use during painful procedures. At this time.

![Figure 1. Percentage of veterinarians using analgesia before and/or after castration in different animals and countries (adapted from Capner et al., 1999; Fajt et al., 2011; Hewson et al., 2006, 2007; Huxley and Whay, 2006; and Lascelles et al., 1999).](https://academic.oup.com/af/article-abstract/2/3/52/4638666)
there are no approved analgesic drugs for controlling
pain in food-producing animals in the United States
(Compendium of Veterinary Products, 2010). However,
the NSAID meloxicam was recently approved for pain
control during dehorning in calves in Canada. Other ap-
proved drugs that have a role in controlling pain include
xylazine, flunixin, ketoprofen, and lidocaine. Use of
any drug for any purpose other than what is indicated
on the label is known as extra label use (Smith et al.,
2008; Coetzee, 2011). Extra label use of a drug may be
permitted for pain control in livestock only under special
circumstances. These include supervision by a veterinar-
ian, approval for animal and human use by either the
Food and Drug Agency (FDA) or Health Canada, and
adherence to drug residue withdrawal times. These fac-
tors only serve to complicate and reduce the likelihood
that drugs falling under these restrictions would be used
readily on a farm.

**Ability to Achieve Analgesia**

It is not the goal of this paper to describe the pharma-
cologic makeup or mode of action of the pain mitigating
drugs presented above but rather the challenges and lim-
itations the veterinary profession and the livestock in-
dustry has in using them to achieve optimal pain control
and therefore animal welfare. A multitude of variables
can interfere in the ability to achieve analgesia in food-
producing animals including both drug and non-drug
related factors (Table 2).

Drug related factors refer to drug attributes such as:
1) their ability to alleviate pain, 2) the speed at which
they take effect, 3) the length of time the effect lasts,
4) whether they can be used alone or best in combina-
tion with other pain control drugs, 5) the mode of deliv-
ery, and 6) the length of time the drug residue remains
(known as withdrawal period which is used to make
sure food is safe). If, for example, it takes 30 minutes
for a drug to take effect after it is administered, its use
becomes impractical in large groups (>50 animals) of
cattle due to the increased duration and additional labor
required to handle the animals. Related to this attribute
of “slow onset” would be the potential for impatient us-
ers to proceed with conducting the procedure before the
drug had reached optimal levels required for effective
pain control. Likewise if a drug(s) only controls pain for
one hour, it may not ultimately be suitable for procedures
that cause both acute and chronic pain lasting well after
that time. Similarly, if the drug has to be re-administered over a number
of days or weeks, it is also impractical when working with large groups
of animals characteristic of many livestock operations. If administration
of the drug(s) requires specialized training and skill, it is less likely to be
used. An example of this is the use of the NSAID flunixin meglumine
that is only approved for intravenous administration (Coetzee, 2011). Fi-
ally, animals destined for human consumption in North America must be
free of drug residues prior to being sent to slaughter. For example, cattle
treated with flunixin meglumine cannot be sent to slaughter for a period of
six days after its administration.

It should be noted that each animal receiving pain control must be
handled and restrained properly, making it a very labor intensive process
for a large number of animals. At this time there are no methods of mass
delivery for pain control drugs such as orally through the feed or water.
Although this would be highly practical and likely to facilitate adoption
by producers, the current limitations include inability to control dosage

![Figure 2. Examples of painful management procedures used in beef cattle and some physiological and behavioral indicators of pain.](https://academic.oup.com/af/article-abstract/2/3/52/4638666)
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(too low, no effect; too high, toxicity and off label use issues) and poor availability of oral preparations of the drug.

Non-drug factors refer to variables such as: 1) the cost of the drug, 2) restrictions regarding who can acquire and deliver the drug, and 3) availability (described earlier). It is not surprising that industry adoption may be low if the cost of the drug(s) is overly high and the industry has no evidence that there is animal or operational benefit such as reduced behavioral signs of pain or improved growth performance. Finally, depending on the drug, there may be legal restrictions on who can obtain and deliver them such as in the case of controlled substance drugs like the opioid butorphanol (Stafford and Mellor, 2005).

Conclusions

The proper management of pain in food-producing animals has become a matter of increasing public concern and growing interest by legislative bodies worldwide. As a consequence the industry must critically evaluate animal management practices and oversee animal care to a far greater extent than in the past, as well as build trust in the public that the welfare and humane treatment of livestock is top priority (Galyean et al., 2011).

At this time there are few standard pain mitigation regimes agreed upon or used by the veterinary community for the procedures described above. It is likely that a combination of pain management techniques will be the most effective. In order for pain mitigation strategies to be actively adopted by the industry, they must be readily available and registered for use, effective against pain, easy to administer, long acting, have short withdrawal periods, show return on investment, and address public wel-

### Table 1. Commonly used food animal analgesic drugs in North America.1

| Classification       | Drug          | Labeled use2 | Dose  | Administration3 | Meat | Milk |
|----------------------|---------------|--------------|-------|-----------------|------|------|
| Local anesthetic     | Lidocaine     | yes          | –     | Infiltration, Epidural | 5     | 4 |
| Dissociative         | Ketamine      | EL4          | 5 to 20 | IM | 3 | 2 |
| α2-agonist           | Xylazine      | yes          | 0.05 to 0.5 | IV | 3 | 2 |
|                     |               |              | 0.05 to 0.5 | IM | 4 | 2 |
| Detomidine           | EL            | 0.01 to 0.02 | IV, IM | 3 | 3 |
| Medetomidine         | EL            | 0.005 to 0.01 | IV, IM, SC | No formal approval |
| Romifidine           | EL            | 0.04 to 0.10 | IV | No formal approval |
| NSAID4               | Ketoprofen    | yes          | 2 | IV, IM, SC | |
|                     | Flunixin meglumine | yes | 1.1 to 2.2 | IV | 6 | 36 |
|                     | Salicylic acid | yes | 100 | PO | 1 | 1 |
|                     | Meloxicam     | yes          | 0.5 | IV, SC | 15 | 5 |
|                     | Carprofen     | EL           | 1.4 | IV, SC | No formal approval |
|                     | Tolfenamic acid | EL | 4 | IV, IM | No formal approval |
| Opioids              | Butorphanol   | EL           | 0.05 to 0.1 | IV | No formal approval |
|                     | Buprenorphine | EL           | 0.005 to 0.01 | IV | No formal approval |

1 Data obtained from Health Canada (2011) and the Food Animal Residue Avoidance and Depletion Program (2011).
2 Refers to drugs labeled for use in cattle and not necessarily labeled for use during painful procedures.
3 IM: Intramuscular; IV: Intravenous; SC: Subcutaneous; PO: Oral.
4 EL: Extra label use.
5 NSAID: Nonsteroidal anti-inflammatory drug.

### Table 2. Factors affecting the ability to achieve analgesia

| Drug related factors | Non-drug related factors |
|----------------------|--------------------------|
| Ability to alleviate pain | Cost of drug |
| Speed at which drug takes effect | Restriction of who can acquire and deliver the drug |
| Length of time the effect lasts | Availability of the drug to use in farm animals |
| Optimal effect as a single drug or in combination with other pain control drugs | |
| Mode of delivery | |
| Withdrawal period | |

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fare concerns. Practical on-farm solutions for pain control in cattle and livestock in general will be facilitated by continued research into pain assessment and its alleviation using a combination of novel and proven techniques.

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