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The effect of a topical anesthetic on the sensitivity of calf dehorning wounds

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ABSTRACT

The objective was to determine the effect of a topical local anesthetic on the sensitivity of dehorning wounds in calves. Thirty 2-mo-old Holstein-Friesian calves were randomly allocated to sham dehorning control (CON), scoop dehorning without treatment with topical anesthetic (SnoTA), or scoop dehorning with an application of a topical anesthetic (STA). Sensitivity was measured by providing mechanical stimulation to the dehorned wound and peri-wound area using von Frey monofilaments calibrated at 10 and 300 g. Calf responses were categorized as absent, minor, moderate, or severe. Sensitivity measurements were performed before treatment and at various time points up to 24 h posttreatment. Sham dehorned calves displayed unchanging absent or minor responses to stimulation. Regardless of whether topical anesthetic was applied, scoop dehorned calves were more likely to display minor, moderate, or severe responses than sham dehorned control calves, and responses tended to be most extreme at 4 h postdehorning. Calves in the STA group tended to be less likely to display minor, moderate, or severe responses than calves in the SnoTA group at most time points (exception at 4 h postdehorning). Responses were significantly more likely to be less severe in STA calves than in SnoTA calves at 40 min and 1.5 h following dehorning. Thus, the use of the topical anesthetic for calves reduced the short-term sensitivity of scoop dehorning wounds.
Key words: dehorning, calf, pain, topical anesthesia

INTRODUCTION

Dehorning is a painful yet important routine husbandry procedure in the global dairy and beef industries. Dehorned cattle are safer to handle and cause fewer injuries to workers, other cattle, and farm animals (Stafford and Mellor, 2005). Cattle are also dehorned to reduce bruising and hide damage, to minimize trough space requirements, and to meet transport requirements (Goonewardene and Hand, 1991; Faulkner and Weary, 2000; Prayaga, 2007). Although the breeding of polled cattle can be viewed as the long-term solution to the problems associated with horned cattle, dehorning will likely continue until all cattle are polled (Prayaga, 2007). In the interim, it can be argued that the provision of pain relief for these animals will enhance animal welfare.

Several dehorning methods exist, including cautery, the use of caustic paste, and amputation. All of these methods involve tissue damage and have been described as painful (Stafford and Mellor, 2005, 2011). Dehorning calves at an early age (before 2 mo) may help mitigate the pain and stress associated with the procedure. Removal of the horn before its attachment to the skull (disbudding) tends to create a more superficial and less traumatic wound, likely resulting in less pain and bleeding and a shorter healing time (Petherick, 2011). Disbudding also allows for possibly less painful methods to be used, including cautery and caustic disbudding (Stafford and Mellor, 2005). The *Model Code of Practice for the Welfare of Animals: Cattle*, however, strongly advises against caustic disbudding (PISC, 2004).

After horn-bud attachment to the skull (usually from about 2 mo of age), more invasive techniques such as amputation dehorning are required (Anderson, 2009). Amputation dehorning has been found to induce abnormal behavior and affect physiological parameters that are likely to be indicative of pain (Stafford and Mellor, 2005). Amputation dehorning induces a significant increase in cortisol concentration that persists for 7 to 9 h (Sylvester et al., 1998a,b). Changes in animal behavior, including increased frequency of head shaking, ear flicking, tail flicking, and reduced rumination, are also suggestive of a painful experience that persists for up to 6 h following dehorning (Sylvester et al., 2004).

Much research has been devoted to the use of pain relief for scoop dehorning pain (peri- and postprocedure), with varying efficacy and duration of anesthesia or analgesia. Different pain relief compounds have been investigated, including local anesthetics, analgesics, and nonsteroidal antiinflammatory drugs. Scoop dehorning with the prior administration of lignocaine (local anesthetic) and ketoprofen (nonsteroidal antiinflammatory drug) has been found as one of the least

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painful methods to dehorn calves, with little change in cortisol concentration detected and relatively normal behavior observed after dehorning (McMeekan et al., 1998b, 1999).

Despite this knowledge, dehorning is commonly performed without pain relief because of the costs and impracticalities associated with researched methods (Petherick, 2005). Current options involve single or multiple intramuscular, subcutaneous, or intravenous injections that must be administered by a veterinarian some time before the dehorning procedure. This can be expensive and may involve double-handling of the animals, adding to the animal's stress and the time required to perform the procedure. Thus, these regimens are in opposition to the financial, labor, and time constraints imposed on commercial production.

Despite these constraints, growing industry requirements for providing pain relief for calves undergoing dehorning must also be considered. The Council of Europe recommends the use of anesthesia for the dehorning of calves over 4 wk of age (Oliver, 2009). Pain control is also required for all calves under the *Canadian Code of Practice for the Care and Handling of Dairy Cattle* (NFACC, 2009). Furthermore, the Australian *Model Code of Practice for the Welfare of Animals: Cattle* recommends the use of local analgesics for dehorning calves over 6 mo of age (PISC, 2004). Thus, the need to meet industry standards and the availability of suitable dehorning pain relief regimens for commercial production remain a challenge.

Topical anesthesia may be a practical and more affordable option for pain alleviation. Administered postoperatively, local anesthetic agents are fast-acting and highly effective when applied to open wounds or mucosal tissues (Bush, 2002; Lomax et al., 2008). The preoperative injection of local anesthetics (cornual block; Weaver et al., 2005) has been found to be effective in reducing pain (cortisol concentrations) for up to 2 h (lignocaine) (Petrie et al., 1996; Sylvester et al., 1998b) and 4 h (bupivacaine) following dehorning (McMeekan et al., 1998a). Cortisol concentrations increase thereafter, suggesting their effectiveness for acute (2–4 h) dehorning pain only. Local anesthesia combined with a nonsteroidal antiinflammatory drug (ketoprofen) has been found to reduce the cortisol response to dehorning (McMeekan et al., 1998b; Sutherland et al., 2002). This suggests that local anesthetics, especially when used with other analgesics, can be effective in minimizing the pain and stress in the hours that follow disbudding or dehorning. The topical application of local anesthetics remains to be evaluated.

For the current experiment, a wound dressing was formulated that was derived from a topical anesthetic formulation originally developed for the relief of mulesing pain in lambs. The formulation (Tri-Solfen, Bayer Animal Health, Gordon, NSW, Australia) contained short-acting (lignocaine) and long-acting (bupivacaine) local anesthetics, adrenaline for hemostasis, and cetrimide to prevent infection. The anesthetic had the added benefit that it was easy to use and could be applied by the farmer. The aim of this experiment was to assess the effect of the postoperative application of a modified topical anesthetic formulation on the sensitivity of scoop-dehorning wounds in dairy calves.

MATERIALS AND METHODS

Animals and Housing

The experiment was approved by the Animal Ethics Committee of The University of Sydney and was conducted on 30 Holstein-Friesian heifer calves aged 8 wk (±1 wk) at the Corstorphine Dairy Unit of The University of Sydney (New South Wales, Australia) in autumn and spring 2010. Corstorphine operates as a commercial dairy that provides animals for research. Calf weights were not able to be taken but were estimated at 45 to 55 kg. Calves close in age (2 mo ± 1 wk) were preferred, thus only a small number of calves were suitable for experimentation on any certain day. The experiment was therefore replicated 3 times to obtain 10 animals in each of the 3 treatment groups. The different experimental days (replicates 1, 2, and 3) were considered blocks. On the each of the days of replicates 1 and 2, 12 calves were available (n = 4 in each treatment group) and on the day of replicate 3, 6 calves were available (n = 2 in each treatment group). The same protocol was followed on each experimental day.

The calves were female replacement heifers raised under commercial operational conditions. They were separated from their dams by 2 d of age and were thereafter group-housed in 1-ha paddocks before and during the experimental period. Calves were fed a milk ration at 10% of their BW twice a day at 0730 and 1530 h via an artificial teat and had ad libitum access to water and kikuyu-based pasture.

Experimental Design and Treatments

On the day of experimentation, calves were moved from their pens to an adjacent holding yard and then into a spinroll calf cradle (Arrow Farmquip, Tamworth, NSW, Australia) in which treatments were imposed on individual calves and data were collected. Calves were placed into lateral recumbency (on right side) while in the cradle as per instruction from the manufacturer. Calves (total n = 30) were randomly assigned to 1 of 3 treatments: sham scoop dehorning (control group,

CON; n = 10), scoop dehorning without application of topical anesthetic (**SnoTA**; n = 10), and scoop dehorning with an immediate application of a topical anesthetic gel (Bayer Animal Health, Gordon, NSW, Australia) (**STA**; n = 10) Calves were sham-dehorned or dehorned between 0830 and 1100 h. Sham-dehorning was performed by manually manipulating and placing scoop dehorners over the horn bud but not incising. Dehorning was performed by placing small scoop dehorners over the horn bud region and pulling apart the handles of the device to excise the horn bud and immediate surrounding skin. The STA calves received approximately 4 mL of topical anesthetic (**TA**) gel on each dehorning wound (total of 8 mL per calf), which was sufficient to cover the dehorning wound and cut skin edges. The gel was applied immediately after excision (within seconds) with a sterile, soft silicone-bristled brush. The TA had a thick, honey-like consistency that, once spread over the horn bud, had a thickness of approximately 2 to 3 mm. The brush was cleaned between calves with a disinfectant solution.

The TA was modified from its original formula (for mulesing) with the intention that it would be more suitable for dehorning wounds. The TA used in this study contained lignocaine (100.0 g/L, as the hydrochloride) and bupivacaine (5.0 g/L, as the hydrochloride), adrenaline (100.0 mg/L, as tartrate), and cetrimide (5.0 g/L). The lignocaine concentration was doubled from the original formulation to produce a concentrated gel more suitable for the smaller surface area of the dehorning wound. The concentration of adrenaline and the viscosity of the gel were also increased with the intention of encouraging increased hemostasis and adherence of the TA to the wound, respectively.

Assessment of Skin and Wound Sensitivity

Quantitative sensory testing (**QST**) was performed using calibrated von Frey monofilaments to assess the sensitivity of the dehorned wound and immediate adjacent area. von Frey monofilaments are instruments that, depending on length and diameter, apply a specific calibrated force to a skin surface. Monofilaments that exerted 10 g (Bailey Instruments Ltd., Salford Quays, UK) and 300 g (Touch Test, Stoelting Company, Wood Dale, IL) of force were used to apply repeatable light-touch and pain stimulation, respectively. The 10-g von Frey was chosen because this force was successfully used in previous lamb experiments (mulesing, castration, and tail-docking) to provide light-touch stimulation (Lomax et al., 2008, 2010). The 300-g von Frey was chosen because this force was successfully used in pilot experiments to elicit greater mechanical stimulation. Sensitivity was assessed by scoring the responses of each calf to the stimulation of 4 sites directly on the dehorned area (wound; left and right wounds) and 2 sites adjacent to each dehorned area (peri-wound; Figure 1). The dehorning wound measured approximately 3 to 4 cm in diameter and chosen sites within the wound were approximately 2 to 3 cm apart (horizontally and vertically). The peri-wound sites were 2 cm from the dehorned wound edge. Four sites within the wound were chosen to obtain an average indication of the whole wound sensitivity, which tends to have changing bone and tissue composition with different innervation. Quantitative sensory testing was performed before dehorning on intact skin and was repeated at 1 and 40 min and 1.5, 4, and 24 h posttreatment.

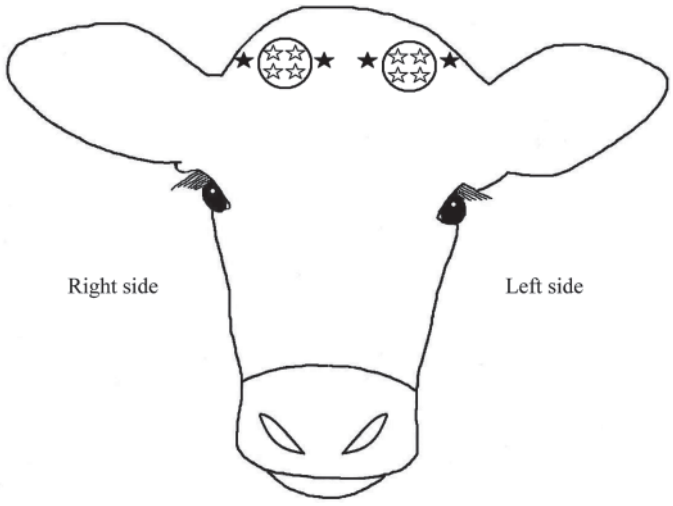

Figure 1. Sites subjected to light touch and pain stimulation sensory testing: directly on the dehorned site (white stars) and adjacent to dehorned site (black stars).

Evidence of local anesthesia, allodynia (pain from normally nonpainful stimuli), and primary and secondary hyperalgesia (increased pain sensation at the site of injury or distant from the site of injury, respectively) were assessed at each site using the von Frey monofilaments. The head and rump responses of calves to light-touch and pain stimulation were observed and subjectively scored. A numerical rating scale was developed to assess facial and head response based on similar work in lambs (Lomax et al., 2008), whereby 0 = no response; 1 = minor facial awareness such as an eye blink or widening or an ear flick; 2 = partial withdrawal reflex such as partial head rotation; and 3 = full withdrawal reflex such as full head jerk or rotation. Rump responses were graded as follows: 0 = no response; 1 = minor involuntary motor response such as local skin twitch, subcutaneous muscle twitch, or anal contraction; 2 = partial rump withdrawal reflex such as multiple subcutaneous muscle group contrac-

tions, including anal contraction; and 3 = full rump withdrawal reflex.

Statistical Analysis

The aim was to evaluate the effect of treatment on response severity to QST. Given that the outcome variable was both categorical (classed) and ordinal (in succession), with $Y = 0$, 1, 2, or 3 indicating increasing levels of pain severity, data were analyzed using ordinal logistic regression using ASReml 3.0 statistical software (Gilmour et al., 2009). The fixed effects of the model were treatment, time (pretreatment, 1 and 40 min and 1.5, 4, and 24 h posttreatment) and their interaction, von Frey monofilament size (10 or 300 g), area tested (wound or peri-wound), observed area (head or rump), head side (left or right side), replicate (replicate 1, 2, or 3), and random effects were calf and time nested within calf, to address clustering of the data. For all statistical calculations, P-values ≤ 0.05 were considered statistically significant.

RESULTS

Overall

We observed a significant time and treatment interaction ($P = 0.004$) and significant effects of von Frey size (10 or 300 g; $P < 0.001$), area observed (head or rump; $P < 0.001$), side of head tested (left or right; $P < 0.001$) on the severity of calf responses to mechanical stimulation. No effect of area tested (wound or peri-wound; $P = 0.076$) or replicate (replicate 1, 2, or 3; $P = 0.056$) was observed. A high amount of between-calf variation was observed in responses.

Time and Treatment Interaction

The overall time and treatment interaction can be observed in Figure 2**.** Before treatment, all calves were 98% likely to display no response ($Y = 0$) to stimulation. Thereafter, CON calves remained highly likely (98–99%) to show no response to stimulation at all time points following sham-dehorning. Dehorned calves, regardless of treatment with or without topical anesthetic (SnoTA and STA calves), tended to show an increase in response severity over time, with calves being more likely to show a minor, moderate, or severe response ($Y = 1$, 2, or 3) after dehorning than before dehorning. Calves in the STA group tended to be less likely to display more severe responses than SnoTA calves at most time points after dehorning.

At 40 min and 1.5 h postdehorning, STA calves were less likely to display more severe responses ($Y = 1$, 2, or 3) to stimulation than SnoTA calves ($P < 0.05$). At these time points, STA calves were 95 to 97% likely to show no response to stimulation compared with 85 to 89% in SnoTA calves. At 1 min and 24 h posttreatment, STA calves tended to be less likely to display more severe responses than SnoTA calves ($P > 0.05$). At 4 h postdehorning, STA and SnoTA calves were likely to display similar responses to stimulation ($P > 0.05$).

von Frey and Area Effects

von Frey size had a significant effect on the severity of calf responses to stimulation ($P < 0.001$). Regardless of treatment, calves were more likely to display higher responses ($Y = 1$, 2, or 3) when stimulated with the 300-g von Frey monofilament than when stimulated by the 10-g von Frey monofilament (8 vs. 2% chance, respectively; Table 1).

With stimulation of the wound using the 10-g von Frey monofilament, STA calves were more likely than SnoTA calves to show no response to stimulation at 1 and 40 min and 1.5 h postdehorning. At these time points, SnoTA calves were 2, 4, and 3 times more likely, respectively, to show mild, moderate, or severe responses than STA calves (Figure 3a). At 4 and 24 h postdehorning, probabilities between these 2 groups were similar. Although wound stimulation with the 300-g von Frey monofilament was more likely to produce more severe responses, stimulation produced similar

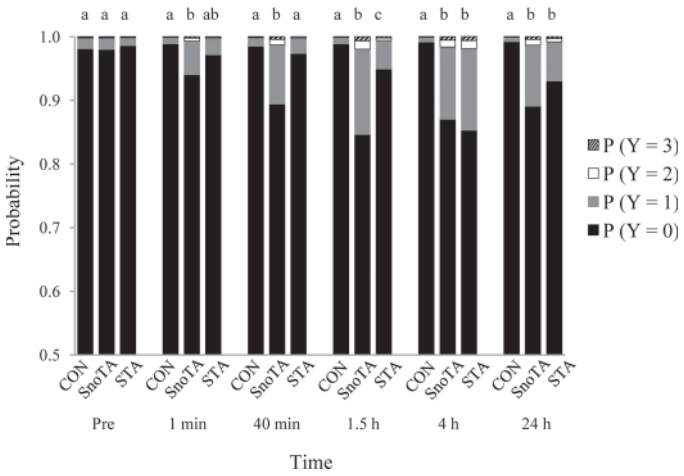

Figure 2. Probability of calves in each treatment group displaying responses (Y; 0 = no response, 1 = minor, 2 = moderate, 3 = severe) at different time points. Results combine the effect of 10-g and 300-g von Frey monofilaments and wound and peri-wound areas (CON = sham dehorned; SnoTA = scoop dehorned and no treatment with topical anesthetic; STA = scoop dehorned and treated with topical anesthetic). [a–c]Within each time point, treatment groups not sharing a common letter are significantly different ($P < 0.05$).

Table 1. The overall effect of von Frey monofilament size (10 or 300 g), observation area (head or rump), and side of the head tested (left or right) on the probability of calves displaying zero, minor, moderate, and severe responses to mechanical stimulation ($Y = 0$, 1, 2, and 3, respectively)

	Response				
Item	$Y = 0$	$Y = 1$	$Y = 2$	$Y = 3$	P-value
von Frey size					<0.001
10 g	0.9845	0.0138	0.0011	0.0006	
300 g	0.9248	0.0663	0.0059	0.0030	
Observation area					<0.001
Head	0.9424	0.0509	0.0044	0.0023	
Rump	0.9795	0.0182	0.0015	0.0008	
Head side					<0.001
Left	0.9603	0.0351	0.0031	0.0015	
Right	0.9700	0.0266	0.0023	0.0011	

proportions of likelihoods as the 10-g von Frey wound stimulation (Figure 3b).

Stimulation of the peri-wound tissue tended to produce similar or slightly less severe responses than direct stimulation of the wound site, although this difference was not significant ($P = 0.076$). Stimulation of this area with the 10-g von Frey resulted in a 98, 95, 93, 94, and 95% chance of SnoTA calves showing no response ($Y = 0$) at 1 and 40 min and 1.5, 4, and 24 h, respectively (Figure 4a). The STA calves were slightly more likely to show no response at 1 and 40 min and 1.5 and 24 h postdehorning (99, 99, 98, and 97%, respectively). At 1 and 40 min and 1.5 h, STA calves were between 2 and 4 times less likely than SnoTA calves to display mild, moderate, or severe responses. At 4 h posttreatment, STA and SnoTA calves showed similar response probabilities, with calves from both treatments being approximately 93 and 94% likely to show no response to stimulation (respectively). Stimulation of the peri-wound area with the 300-g von Frey produced more severe responses in SnoTA than STA calves, except at 4 h posttreatment, when the responses were equal (Figure 4b). At 1 and 40 min and 1.5 h postdehorning, STA calves were between 2 and 4 times less likely than SnoTA calves to show more severe responses ($Y = 1$, 2, or 3). At 24 h postdehorning, STA calves were more likely to not respond ($Y = 0$) to stimulation than SnoTA calves (86 vs. 80%, respectively).

Observation Area Effect

The severity of responses differed significantly between stimulation of the head compared with the rump area ($P < 0.001$). Overall, regardless of treatment, head responses tended to be more severe than rump responses (Table 1).

Head Side Effect

We found a significant difference comparing each side of the head tested on the response severity of calves to stimulation ($P < 0.001$), with calves tending to display more severe responses when stimulated on the left compared with the right side of the head (Table 1).

We observed benefits from the more viscous and concentrated formulation compared with the original aqueous TA. In contrast to the original formula, the new TA was able to be effectively applied onto the dehorning wound and adhered well immediately after application. The TA was able to momentarily delay, but not stop, bleeding from the wound, and adherence diminished once arterial bleeding commenced. Adherence of the TA to the adjacent intact skin was observed 24 h postapplication.

DISCUSSION

The immediate treatment of wounds with a TA following scoop dehorning was able to reduce wound sensitivity for up to 1.5 h after application. This finding suggests that the application of topical anesthesia can provide some anesthetic effect, albeit short-term, thus likely reducing the postoperative acute pain from scoop dehorning in 2-mo-old dairy calves. The present experiment also provides new information on the extent and progression of the sensitivity of dehorned wounds, and the effect of topical anesthesia, as assessed through QST.

Local anesthetics act directly on nervous tissue to block the conduction of nerve impulses (Flecknell, 1996). Research into the use of local anesthesia for alleviating dehorning pain has been extensive and indicates that preoperative administration of the local anesthetic lignocaine (cornual block; Weaver et al., 2005) is able to largely eliminate the cortisol response during the first 2 h after amputation dehorning (Petrie et al., 1996; Sylvester et al., 1998b). The TA formulation developed for use in the present experiment was derived from a commercially available topical anesthetic (Tri-Solfen, Bayer Animal Health) and contained lignocaine and bupivacaine. Both are local anesthetic agents that pro-

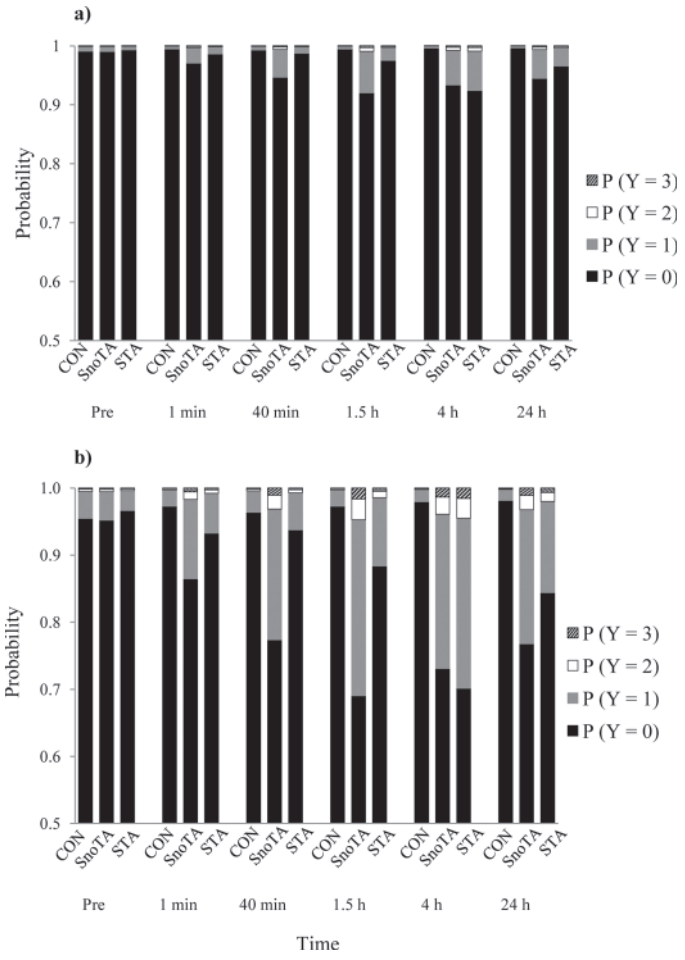

Figure 3. Probability of calves in each treatment group displaying responses (Y; 0 = no response, 1 = minor response, 2 = moderate response, 3 = severe response) upon stimulation of the wound with 10-g (a) and 300-g (b) von Frey monofilaments (CON = sham dehorned; SnoTA = scoop dehorned and no treatment with topical anesthetic; STA = scoop dehorned and treated with topical anesthetic).

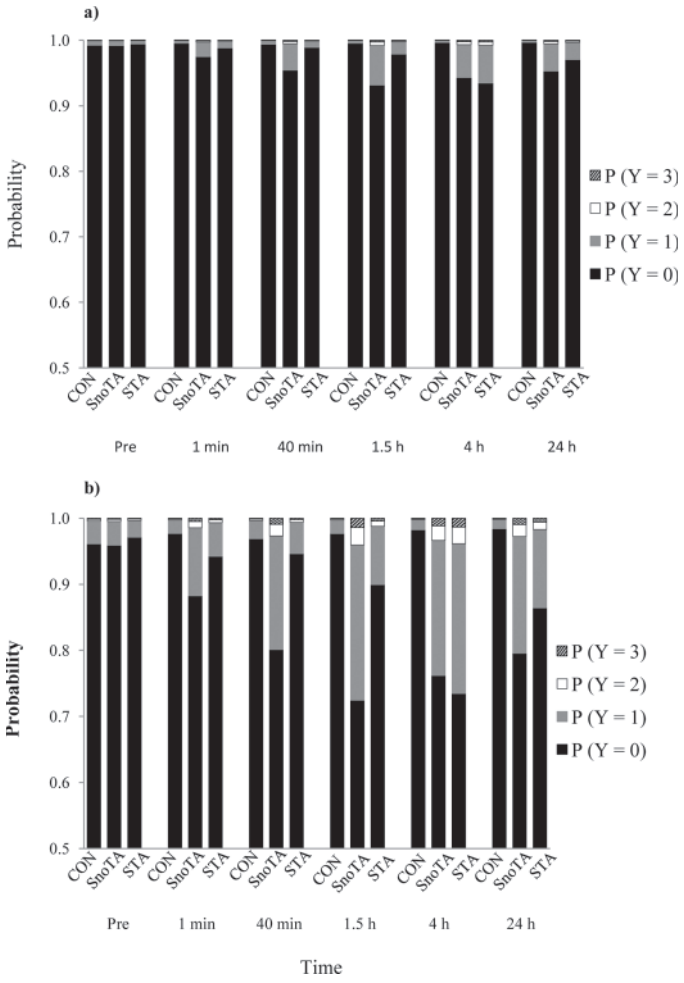

Figure 4. Probability of calves in each treatment group displaying responses (Y; 0 = no response, 1 = minor response, 2 = moderate response, 3 = severe response) upon stimulation of the peri-wound area with 10-g (a) and 300-g (b) von Frey monofilaments (CON = sham dehorned; SnoTA = scoop dehorned and no treatment with topical anesthetic; STA = scoop dehorned and treated with topical anesthetic).

vide intermediate (1–2 h) and long-acting (3–7 h) relief from pain, respectively (AHFS, 2012). The formulation also contained adrenalin, which causes vasoconstriction, promotes hemostasis, and slows the systemic absorption of local anesthetics, helping to prolong their effect on tissues (Lomax et al., 2008). The local anesthetics and adrenalin, as combined in the experimental TA gel, were present in concentrations similar to those providing effective anesthesia and hemostasis in humans and lambs, while still below toxic thresholds for lambs (Bush, 2002; Lomax et al., 2008).

The formulation used in this experiment was developed specifically for use on scoop-dehorning wounds in calves. The small wound size and mucosal surface area and the potential high blood loss from arterial bleeding associated with scoop dehorning presented different challenges compared with the wounds resulting from mulesing in lambs, for which the original formulation was developed. From our observations, the new formulation achieved greater adherence to the wound and peri-wound area than did the original formulation. This was likely due to the higher viscosity of the new TA compared with the more aqueous original formulation. It is important to note that this adherence to the wound appeared to diminish with arterial bleeding, suggesting that the increased concentration of adrenalin in the new formulation was ineffective at combating heavy blood flow.

von Frey monofilaments provide a specific, calibrated force to a skin surface. These filaments are advantageous for pain assessment as they can easily be used to provide repeatable mechanical stimulation to a subject to gauge skin or wound surface sensitivity and its pro-

gression over time. Thus, QST with von Frey monofilaments was chosen to assess the efficacy of the TA as this approach was believed to provide a good indication of the extent and progression of local anesthesia and pain sensitivity over time. Although cortisol concentration is commonly used as a measure of pain, the hormone only provides a relative indication of the overall noxiousness or stress of an experience. Nonpainful external stressors, including handling, restraint, and the presence of dogs or humans, can also cause cortisol concentrations to increase (Kilgour and de Langen, 1970; Mears et al., 1999). In addition, cortisol concentrations have been shown to increase even in the absence of pain, such as during surgical procedures under general anesthesia, as cortisol plays an important role in maintaining blood volume (Fox et al., 1994; Hughan et al., 2001). Furthermore, although the quantification of behavioral response is a validated measure of pain in calves, some behaviors associated with (scoop) dehorning, such as ear flicking and head shaking, may occur due to the irritation of flies or blood loss, rather than to pain per se (Stafford and Mellor, 2006). von Frey monofilaments have been used in previous studies to assess different analgesic interventions in humans and animals (Brennan et al., 1996; Keizer et al., 2007; Lomax et al., 2008). In the present study, von Frey monofilaments were used for the first time to gauge the sensitivity and anesthesia of dehorning wounds with and without the application of a TA. The results indicate an increase in the sensitivity of the dehorned wound site and adjacent area, regardless of treatment with or without the TA, which persisted at higher levels compared with the control animals, for up to 24 h postdehorning.

Light touch stimulation of the wound and peri-wound area showed an increase in allodynia in scoop dehorned calves. Regardless of treatment with or without TA, dehorned calves showed an increased likelihood of displaying more vigorous reflex responses than calves that were sham-dehorned. This suggests the presence of, and increase in, allodynia of damaged tissues over time. Similarly, more painful stimulation of these sites (with the 300-g von Frey monofilament) showed increasing primary and secondary hyperalgesia, which peaked 4 h postdehorning.

Application of TA demonstrated that a significant reduction in sensitivity could be achieved. The TA significantly reduced wound sensitivity at 40 min and 1.5 h postdehorning in treated calves. This demonstrated that lignocaine and bupivacaine were effectively absorbed from the dehorning wound, resulting in local anesthesia. Furthermore, at 1 min postdehorning, STA calves, although not significantly different compared with SnoTA calves, were also not different from CON calves, suggesting an intermediate effect and rapid onset of anesthesia.

Similar sensitivity between SnoTA and STA calves at 4 h may signify waning efficacy of bupivacaine in the formulation. At 4 h, the lower sensitivity in STA, compared with SnoTA calves, that was observed at most time points was not observed. This result was unexpected given that i.v. administration of bupivacaine is generally thought to last 3 to 7 h (AHFS, 2012) and 4 h after scoop dehorning in 3- to 4-mo-old calves (McMeekan et al., 1998a,b). In addition, the inclusion of adrenaline prolongs the activity of local anesthetics by slowing absorption into the bloodstream at the site of application. However, little documentation exists on the topical application of bupivacaine (and lignocaine) in calves. Research investigating the use of topical anesthesia to provide anesthesia for mulesed lambs reported efficacy for up to 8 h posttreatment (Lomax et al., 2008). In the present experiment, the pain sensitivity at 4 h may have been affected by the diminished adherence of the TA observed once heavy bleeding commenced, which led to reduced efficacy of the local anesthetics. Effective and lasting TA to wound contact is important for the absorption and efficacy of topical local anesthesia. Responses at 4 h may also have been affected by calf hunger or agitation, as this time point was the fourth and final of the day and close to feeding time. The high between-calf variation in response to stimulation may also have contributed to the varied responses at this time point.

The onset of anesthesia from the TA is relatively uncertain, with a reduction in sensitivity observed 1 min following application, although this was not statistically significant. Inference from other studies on the topical application of local anesthetics for the relief of surgical pain from husbandry procedures in lambs and calves suggests that the onset of anesthesia may occur between 1 and 3 min postapplication (Lomax et al., 2008, 2010). Although not directly comparable, the onset of anesthesia from the preoperative administration of lignocaine (cornual block; Weaver et al., 2005) for dehorning is approximately 3 to 5 min. Thus, TA probably has a more rapid onset as agents are rapidly absorbed from the exposed mucosa.

Other factors found to affect the severity of response to QST included the part of the body observed (head vs. rump) and side of the head tested (left vs. right). Calves tended to display more severe head than rump responses, which may be due to increased avoidance closer to the site of stimulation or to restriction of calf body movement in the calf crush. Given that the calves were placed in lateral recumbency on the right side may explain why calves tended to display more severe

responses when the left side of the horn and peri-wound were stimulated; the calf's head had restricted movement to the right sight side, thus limiting the response vigor of the calf's head to that side.

No significant difference in sensitivity was observed between the dehorned wound site and the undamaged adjacent area. This may be due to the bony nature of the dehorned wound in 2-mo-old Holstein Friesian calves, which are likely to have little to no innervation or sensory tissue to respond to stimulation. The use of algometry to determine the mechanical nociceptive threshold may provide a clearer indication of sensitivity at these 2 sites and will likely help address the low responsiveness of the calves to von Frey stimulation. Heinrich et al. (2010) successfully used pressure algometry to gauge the mechanical nociceptive threshold of calves undergoing dehorning with local anesthesia with or without a nonsteroidal antiinflammatory drug. Furthermore, this experiment could be further improved by assessing sensitivity of the incised skin edge of the wound, which Lomax et al. (2008) found to be highly sensitive in mulesed lambs.

Local anesthetics generally have poor skin permeability, which limits their use for effective preprocedural skin anesthesia (Lomax et al., 2008). However, the benefit in the postprocedural application of local anesthetics lies in the rapidity and efficacy when they are applied directly to open wounds (Bush, 2002; Lomax et al., 2008). Pain relief for dehorning could be further enhanced by developing and including a long-acting analgesic for a more holistic pain management regimen.

CONCLUSIONS

A postoperative topical anesthetic applied to scoop dehorned 2-mo-old dairy calves was able to provide short-term wound anesthesia, and thus has the potential to significantly reduce postoperative pain associated with scoop dehorning. The incorporation of effective and practical pain relief to address the pain of the procedure and long-term pain could further enhance the welfare of calves undergoing this procedure and facilitate the adoption of a pain relief regimen into commercial dairy production.

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