Duration of action of a topical anaesthetic formulation for pain management of mulesing in sheep

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Objective To investigate the effect of topical anaesthesia on 'mothering up' of lambs after mulesing and marking, and for pain alleviation over a 24-h period.

Design Two separate trials were performed on Merino lambs undergoing the mules procedure for flystrike prevention, to assess the efficacy of immediate postoperative topical anaesthetic wound dressing containing lignocaine (hydrochloride) 40.6 g/L, bupivacaine (hydrochloride) 4.5 g/L, adrenaline (tartrate) 24.8 mg/L and cetrimide 5.0 g/L in a gel base (Bayer Animal Health, Gordon, NSW, Australia).

Methods In both trials, lambs were assigned to one of three treatment regimens: control, mules procedure with topical anaesthetic (0.5 mL/kg) and mules procedure without topical anaesthetic treatment. Parameters measured included body weight, assessment of skin and wound sensitivity to light touch and pain stimulation, behavioural responses and time to mother up and to feed.

Results In both trials there was rapid (1 min) and prolonged (up to 24 h) wound analgesia as shown by lower scores for light touch ($P < 0.001$) and pain responses ($P < 0.001$), with absent or significantly diminished primary and secondary hyperalgesia ($P \leq 0.05$) and significant reduction in pain-related behaviours ($P < 0.001$) in treated versus untreated lambs.

Conclusion Significant pain alleviation and improved recovery can be achieved in lambs for at least 24 h after mulesing through the use of topical anaesthesia. It is suggested that the haemostatic action of adrenalin, together with inhibition of the inflammatory cascade and the barrier effect of the gel within the product, may explain the prolonged anaesthesia up to 24 h observed in the present study. These results suggest that topical anaesthesia has the capacity to dramatically improve the welfare of lambs undergoing mulesing.

Keywords allodynia; flystrike; hyperalgesia; mulesing; sheep; von Frey monofilament

Abbreviations HI, hot iron; LT, light touch; NRS, numerical rating scale; NSAID, non-steroidal antiinflammatory drug

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Flystrike is one of the most significant health and welfare concerns for the Australian and New Zealand sheep industries. It is a disease resulting from the infestation of living tissue by fly larvae, initiated by oviposition by the sheep blowfly *Lucilia cuprina*.

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Breech strike involving infestation of the 'crutch' or perineal region is the most common form of blowfly strike, occurring to some degree in almost every susceptible flock each year in Australia.[1–4]

The mules procedure, developed in the 1930s, involves the removal of the folds of skin from the breech area of sheep in order to decrease susceptibility to oviposition by *L. cuprina* through reduced moisture and faeces retention. It is widely accepted as the most effective method for the lifetime prevention of breech strike.[5]

Despite the preventive health benefits, there has been growing concern regarding the welfare impact of the procedure itself. In the past, the procedure was undertaken without analgesia, resulting in evidence of acute pain and stress.[6–9] The Australian Wool Industry has faced increasing pressure in recent years to develop alternative, more humane methods of flystrike prevention to support a phase-out of the mules procedure. The ultimate solution is believed to lie in breeding sheep resistant to breech strike (such that mulesing is no longer required). Intensive genetic research and breeding programmes are underway, but this is a long-term objective.[10–12] Additional research is targeting the more immediate goal of developing more humane practices to deal with breech wrinkle.

In 2005 in Australia, a multifunction topical anaesthetic, antiseptic and haemostatic wound dressing (Tri-Solfen®, Bayer Animal Health, Gordon, NSW, Australia) became available for use on permit through veterinarians for immediate post-procedural application to mulesing wounds in sheep. Tri-Solfen® is a spray-on topical anaesthetic, haemostatic and antiseptic gel agent consisting of lignocaine (40.6 g/L), bupivacaine (4.5 g/L), adrenalin (24.8 mg/L) and cetrimide (5.0 g/L). We have been examining the efficacy of this form of treatment to both alleviate pain and enhance wound healing and recovery in the first 8 h after the procedure. Our studies indicate that significant wound desensitisation, improved lamb recovery rates and enhanced wound healing can be achieved.[13]

Observations during our studies, together with anecdotal reports of improved lamb behaviour up to 24 h post-mulesing, led us to hypothesise that treatment with the topical anaesthetic product may effect a prolonged analgesic response because of inhibition of the pain escalation response.

The mother–lamb bond is important to lamb survival early in life and it can be disrupted by human interventions, particularly in Merino ewes, which have the reputation of being poor mothers.[14] In commercial farm situations, lambs are returned immediately to pasture with their mothers following husbandry procedures such as mulesing. This process is referred to as 'mothering up' and is important for improved lamb recovery because the first feed of milk leads to a rise in endorphins, which can ameliorate acute pain. Additionally, lambs that have a delay in the time to mother up are more susceptible to exposure, including hypothermia and dehydration, which can lead to morbidity and in some cases mortality.[14] There are no discrete data in the literature describing the effects of mulesing on the time to mother up and feed in lambs, despite the painful nature of the procedure. This information has the potential to provide us with a simple tool to assess lamb discomfort and determine the efficacy of pain management regimens for improving lamb recovery post-mulesing.

In the present study, we examined the effect of mulesing on mothering up of lambs following mulesing and marking, and the duration of efficacy of a topical anaesthetic for improving lamb recovery and alleviating pain over a 24-h period.

Materials and methods

Two trials were performed on 6–8-week-old Merino lambs from a commercial flock in the Southern Highlands, New South Wales, Australia. All animal procedures were conducted with prior institutional animal ethics approval in accordance with the National Health and Medical Research Council's *Code of Practice for the Care and Use of Animals for Scientific Purposes*. The trials were conducted in July 2008 (Trial 1; n = 23) on lambs undergoing both mulesing and hot-iron (HI) tail docking and in January 2009 (Trial 2; n = 42) on lambs undergoing mulesing only (previously tail docked). The mean initial body weight of lambs in Trial 1 was 11.89 ± 0.3 kg and for lambs in Trial 2 it was 21.04 ± 0.5 kg. In both trials, lambs were assigned to one of the following treatment regimens, randomised within each trial (Table 1): (1) control, in which lambs were handled but remained unmulesed (or tail docked in Trial 1); (2) mulesing (and HI tail docking in Trial 1) with immediate postoperative topical anaesthetic wound dressing (6–12 mL of Tri-Solfen® sprayed onto wound); (3) mulesing (with HI tail docking in Trial 1) without topical anaesthetic dressing; and (4) HI tail docking only (Trial 1, behavioural observations as described later).

General management and marking

On the day of each trial, lambs were yarded and drafted from their dams into a holding yard where they were held separately from their dams for 4 h. They were then selected at random, weighed and spray-marked numerically and placed in marking cradles. Preoperative skin sensitivity to light touch (LT) and pain stimulation was recorded (see later). Mulesing was performed using a standard 'V'-modified technique. In Trial 1, the HI tail docking was performed using a gas tail-docking knife that had been preheated to the correct temperature to efficiently seal the coccygeal blood vessels. The skin of the tail was pushed towards the lamb's body to locate the correct position between coccygeal vertebrae 2 and 3 and the tail elevated to avoid burning of the perineum. The lever of the knife was squeezed and after 2 s the tail was removed. In lambs assigned to treatment group 2, Tri-Solfen® was applied directly to the mulesing and tail-docking wounds using a metered dose applicator (6–12 mL, based on lamb weight) immediately after the procedure(s). Postoperative skin and wound sensitivity testing was repeated at 1 min post-procedure. Lambs were returned to their dams in a 6 × 4 m pen, where the time taken for lambs to find their dams and feed was recorded. The ewes and lambs were then moved to one of three pasture-covered holding yards (20 × 10 m) in mixed treatment groups and left undisturbed for 24 h. At 1 h and 24 h post-mulesing, the behavioural response scores were recorded (Trial 1) as described later. At 24 h after the behavioural assessment (Trial 1), lambs were then re-drafted, weighed and skin and wound sensitivity testing was repeated.

Table 1. Treatment groups and total number of lambs in each treatment group in Trials 1 and 2

Group	No. of lambs	Mulesing	Tail docking	Treatment
Trial 1				
1	5	No	No	Control
2	6	Yes	Hot iron	Topical anaesthetic
3	6	Yes	Hot iron	No anaesthetic
4	6	No	Hot iron	No anaesthetic
Trial 2				
1	14	No	No	Control
2	14	Yes	No	Topical anaesthetic
3	14	Yes	No	No anaesthetic

Body weights

Weights were recorded using digital scales (Rudweigh®, Gallagher Animal Management Systems, Australia), which were calibrated and zeroed prior to each measurement and accurate to 0.1 kg.

Assessment of skin and wound sensitivity to light touch and pain stimulation

Skin and wound sensitivity was assessed at five predetermined sites on the skin surrounding the mulesing wound and nine sites within the mulesing wound before and then 1 min and 24 h after mulesing using weighted von Frey monofilaments, which are calibrated to bend at predetermined pressures to provide repeatable LT (10 N) and pain (75 N) stimulation of the wound, as previously described.[13]

Evidence of local anaesthesia, primary (wound) and secondary (tissue surrounding wound) allodynia (pain response to non-painful stimuli) and hyperalgesia (exaggerated response to painful stimuli) were assessed at each site. Typical LT- and pain-induced involuntary reflexes and motor responses in the rump and head were measured using a customised numerical rating scale (NRS).[13] Rump response scores were graded as: 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 contraction and/or lifting of the tail; 3, full rump withdrawal reflex with lifting of the rump off the cradle. Facial response scores were graded as: 0, no response; 1, minor facial 'awareness' such as eye widening, blinking or nasal flaring; 2, partial startle reflex of the head such as slight lifting of the snout or partial head rotation; 3, full startle reflex of the head, resulting in a major movement such as lifting the head off the cradle, full head jerk or full head rotation. Scores for each site were added to achieve a total score for each lamb. Total scores were calculated out of 30 for skin sensitivity around the mulesed area and out of 54 for direct wound sensitivity.

Measurement of times to mother up and to feed

Lambs aged 6–8 weeks from 3-year-old ewes were used for these trials. In each trial, lambs and mothers (dams) were observed in groups of mixed treatment. Lambs and dams were identified in pairs by coloured marker for observation of times to mother up and to feed. In Trial 1, there were three groups of 7–8 lambs and dams and in Trial 2, six groups of 7. There were no twins included in the trial.

Time (s) taken for individual lambs to find their mother, and to feed were recorded using a stopwatch (DSE® digital LCD). Time to mother up was measured as time taken for the lamb to locate and be recognised by its mother from its time of release into the yard. Time to feed was measured as the time taken for the lamb to begin suckling from the ewe from its time of release from the yard. This did not always happen simultaneously with mothering up.

During Trial 1, we observed that several ewes displayed circling behaviour when lambs attempted to feed, delaying the time to feed response. We postulated that the odour from singed wool associated with the HI tail docking wound might have been confusing the ewes and thus confounding the response. To investigate this further, a fourth group of lambs that underwent HI tail docking only (n = 6, no mulesing, and no topical anaesthetic treatment) was included to assess the times to mother up and to feed. These lambs underwent the same treatment sequence and were released individually into the pen of the six dams immediately following treatment.

Assessment of pain-related behaviours

In Trial 1, pain-related behaviour was assessed at 1 h and 24 h post-mulesing using the NRS developed previously.[13] A trained observer (experienced animal scientist 'blind to treatment') observed the lambs 24 h post-procedure. Individual lambs were given a score between 0 and 3: 0, no pain-related behaviour; 1, mild abnormalities of posture, gait or behaviour such as mild kyphosis without hyperextension of hindlegs, ventral recumbency with hindlegs partially extended or mild stiffening of gait without overt limping or leg dragging; 2, moderate abnormalities of posture, gait or behaviour such as 'statue standing' with head down and prominent kyphosis, moderate stiffening or slowing of gait or hyperextension and/or abduction of hindlegs, ventral recumbency with hindlegs fully extended; 3, display of severe abnormalities of posture, gait or behaviour such as marked agitation with twisting or writhing, high frequency of postural change from lying to kneeling or standing, distressed vocalisation, lateral or prostrate lying, kneeling, dog sitting or tremors, shaking or lip curling.

Statistical analysis

Data were analysed using GenStat® version 10.0 (VSN International Ltd, Hemel Hempstead, UK). One-way analysis of variance was used to measure effects of treatment on times to mother up and to feed. Data were tested for normality and where necessary transformed into a logarithm form to normalise distribution. A repeated measures residual maximum likelihood estimation for linear mixed models was used to analyse weight data and NRS scores from sensitivity testing and behavioural observations. For all treatments, where a significant time and treatment interaction was found, post-hoc pair-wise comparisons using least significant differences were performed to compare differences within time-points. For all statistical calculations, $P < 0.05$ was considered statistically significant.

Results

Body weights

Trial 1. The change in body weight from pretreatment (11.86 ± 0.32 kg) to 24 h post-treatment (12.26 ± 0.32 kg) was significant ($P = 0.03$). Treatment ($P = 0.59$) and treatment by time interaction ($P = 0.297$) were not significant.

Trial 2. The change in body weight from pretreatment (21.05 ± 0.49 kg) to 24 h post-treatment (20.48 ± 0.45 kg) was not significant ($P = 0.404$). Treatment ($P = 0.737$) and treatment by time interaction ($P = 0.999$) were not significant.

Times to mother up and to feed

Trial 1. Results from Trial 1 are displayed in Figure 1. Lambs that had been HI tail docked with or without mulesing and/or treatment with topical anaesthetic dressing had significantly ($P < 0.05$) longer mean times to mother up and to feed than undocked/unmulesed control lambs. Behaviour of ewes, including circling of lambs and smelling of the perineum, was noted when lambs were placed in the pen with dams. There was no significant difference in time to mother up ($P \geq 0.13$) or time to first feed ($P \geq 0.12$) between any of the groups of lambs that were HI tail docked, regardless of mulesing treatment.

Trial 2. Results from Trial 2 are displayed in Figure 2. Lambs in this group had been previously tail docked and thus underwent mulesing only. Field observations indicated that dams did not display the circling avoidance behaviour that had characterised observations in the Trial 1 groups of lambs that had undergone HI tail docking. This was reflected in the time to mother up, which did not differ significantly between the groups and was similar to the control group from Trial 1. However, there was a trend towards a treatment effect on time to feed, although not significant ($P = 0.1$). Mulesed, non-anaesthetised lambs took longer to begin suckling (38 s) than either control lambs (22 s) or mulesed lambs treated with topical anaesthesia (12 s).

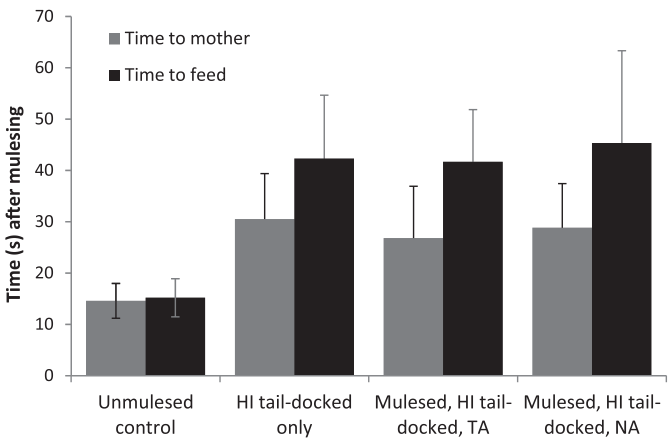

Figure 1. **Mean ± SEM times taken for lambs in Trial 1 to mother up and to feed immediately after treatment. HI, hot iron; TA, topical anaesthesia (Tri-Solfen®); NA, no anaesthesia.**

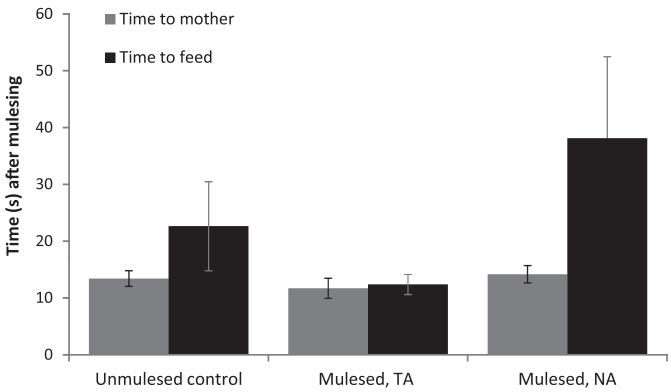

Figure 2. Mean ± SEM times taken for lambs in Trial 2 to mother up and to feed immediately after treatment. Lambs in Trial 2 had been tail docked prior to mulesing. TA, topical anaesthesia (Tri-Solfen®); NA, no anaesthesia.

Response to light touch and pain stimulation of the wound and surrounding skin

Pre-mulesing. There was very little to no response to LT or pain stimulation of the intact skin of the breech prior to mulesing. Mean response scores from the five LT testing sites (maximum possible score of 30) and nine pain sites (maximum possible score of 54) were $\leq 0.04 \pm 0.04$ and $\leq 0.75 \pm 0.22$, respectively, across both trials. There were no significant differences between groups within each trial.

Post-mulesing. Mean responses to pain and LT stimulation of the wound and peri-wound in Trial 1 are shown in Figures 3 and 4, respectively. There was significant effect of treatment on responses to pain and LT stimulation of the wound (both $P < 0.001$) and peri-wound (both $P < 0.001$). A significant time by treatment interaction was also seen for LT and pain stimulation of the wound (both $P < 0.001$) and pain stimulation of the peri-wound ($P < 0.001$). Primary hyperalgesia

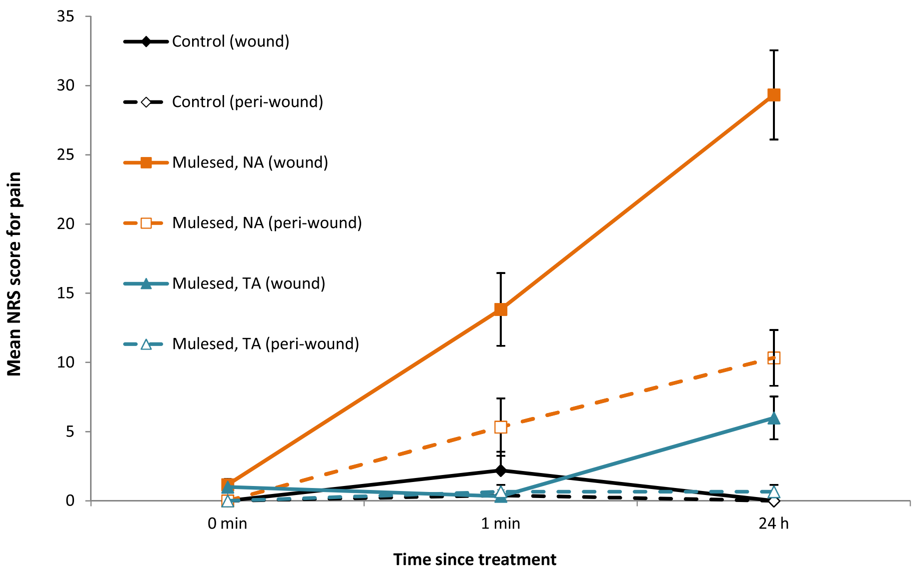

Figure 3. Mean ± SEM total head and rump response scores to pain stimulation of the wound and peri-wound surfaces before (0 min) and after treatment (Trial 1). TA, topical anaesthesia (Tri-Solfen®); NA, no anaesthesia.

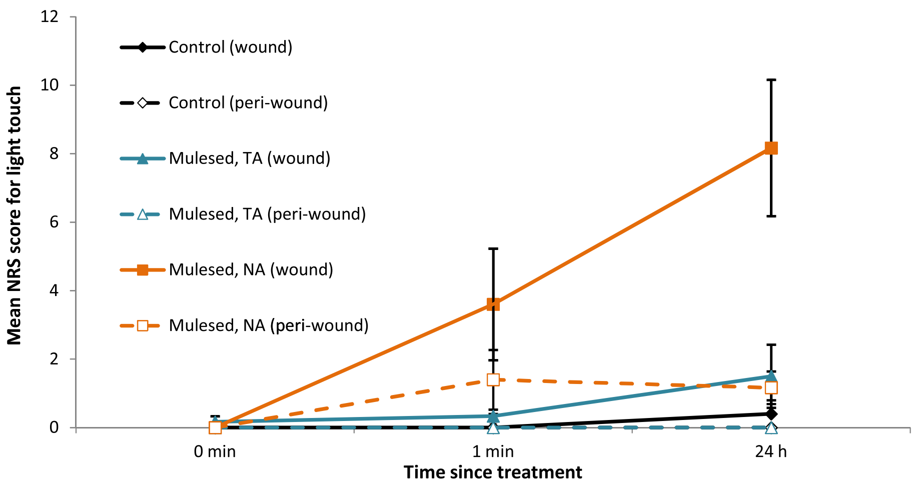

Figure 4. Mean ± SEM total head and rump response scores to light touch stimulation of the wound and peri-wound surfaces before (0 min) and after treatment (Trial 1). TA, topical anaesthesia (Tri-Solfen®); NA, no anaesthesia.

and allodynia (of the wound) developed within 1 min of mulesing in non-anaesthetised lambs, but not in lambs in the control group or mulesed lambs that received topical anaesthesia. Mulesed lambs that received topical anaesthesia also exhibited significantly less secondary hyperalgesia (P < 0.001) and allodynia (P = 0.05) than mulesed, non-anaesthetised lambs. Response scores of mulesed, non-anaesthetised lambs to LT and pain stimulation of the mulesing wound were significantly higher than those of the control lambs and mulesed lambs that received topical anaesthesia, at both 1 min and 24 h post-mulesing.

Mean responses to pain and LT stimulation of the wound and peri-wound in Trial 2 are shown in Figures 5 and 6, respectively. There was a significant effect of treatment (P < 0.001) and time by treatment interaction in responses to pain stimulation of the mulesing wound (P < 0.001) and surrounding skin (P = 0.016). Primary and secondary hyperalgesia developed within 1 min of mulesing in non-anaesthetised lambs, but not in control lambs and mulesed lambs that received topical anaesthesia. Mulesed lambs treated with topical anaesthesia had significantly lower response scores to pain stimulation of the mulesing wound (P < 0.001) and surrounding skin (P = 0.016) at 1 min and 24 h post-mulesing than mulesed, non-anaesthetised lambs. Primary and secondary hyperalgesia response scores of mulesed lambs that received topical anaesthesia did not differ significantly from controls until 24 h post-mulesing. There was no significant difference in primary or secondary allodynia found between treatment groups, despite a trend for mulesed, non-anaesthetised lambs to have higher NRS scores than mulesed lambs that received topical anaesthesia and control lambs.

Pain-related behaviour

Trial 1. Behavioural data are shown in Figure 7. There was a significant effect of treatment (P < 0.001), but no significant treatment by time interaction. Mulesed lambs treated with topical anaesthetic

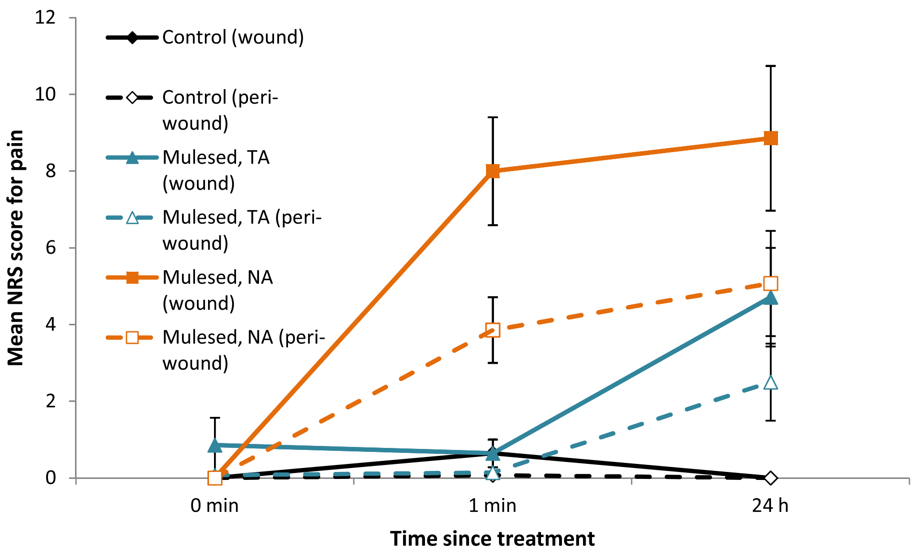

Figure 5. Mean ± SEM total head and rump response scores to pain stimulation of the wound and peri-wound surfaces before (0 min) and after treatment (Trial 2). TA, topical anaesthesia (Tri-Solfen®); NA, no anaesthesia.

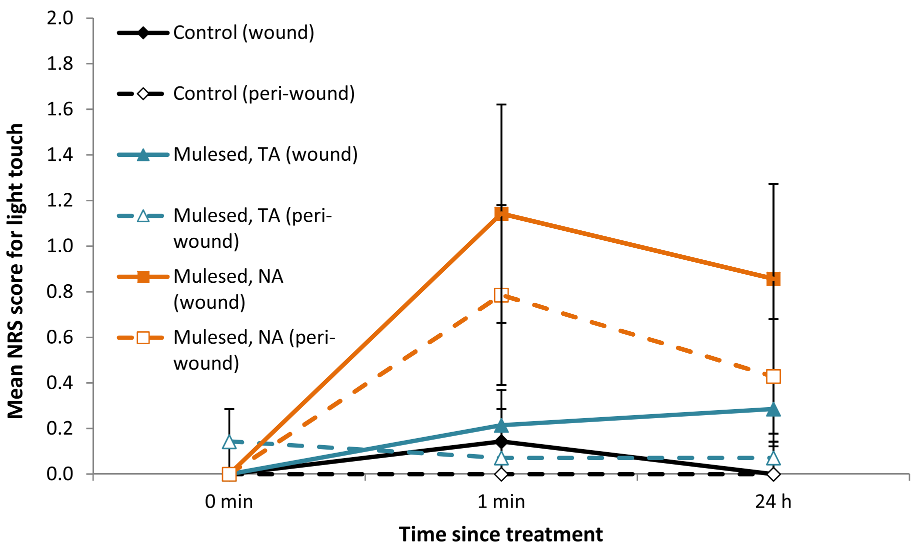

Figure 6. Mean ± SEM total head and rump response scores to light touch stimulation of the wound and peri-wound surfaces before (0 min) and after treatment (Trial 2). TA, topical anaesthesia (Tri-Solfen®); NA, no anaesthesia.

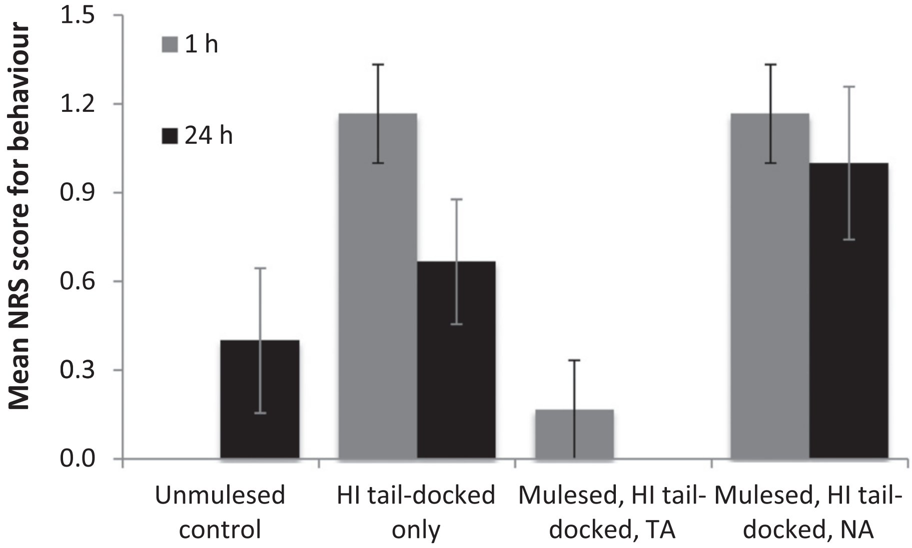

Figure 7. Mean ± SEM numerical rating scores for pain-related behaviour of three different treatment groups of lambs following mulesing and/or tail docking compared with control lambs at 1 h (grey) and 24 h (black) after mulesing (Trial 1). HI, hot iron; TA, topical anaesthesia (Tri-Solfen®); NA, no anaesthesia.

displayed significantly lower pain-related behaviour scores compared with mulesed, non-anaesthetised lambs at both 1 h and 24 h post-mulesing. Mulesed lambs treated with topical anaesthetic did not differ significantly from unmulesed controls.

Discussion

Results from our trials indicate that significant pain alleviation and improved recovery can be achieved in lambs for up to 24 h after mulesing through the use of topical anaesthesia. This extends data from previous research that topical anaesthesia is efficacious up to 8 h post-mulesing.[13,15]

In Trial 1, HI tail docking seems to have been the major factor delaying the times to mother up and to feed. This could be attributed to the invasive nature of the procedure, as it is well documented that tail docking elicits a significant pain response in lambs.[9,16–18] It is also hypothesised that the odour of the cauterised wound may act as a deterrent to the mother when lambs approach them and this was observed through the avoidance behaviour displayed by the ewes to the lambs, evident in Trial 1, but not in Trial 2 where lambs were mulesed without tail docking. Ewes in Trial 1 appeared to spend more time smelling the lambs, particularly the perineum, before allowing contact and eventually, feeding. However, it is important to note that differences between groups were only a matter of seconds and are therefore not likely to be clinically relevant. Further analysis of this phenomenon may provide useful information to researchers and producers as to how mothering up can be affected by various husbandry procedures.

In Trial 2, unrecorded observations suggested that pain-related behaviour may have interfered with feed-seeking behaviour in some lambs undergoing mulesing without topical anaesthesia, but this was not apparent in control lambs or lambs treated with topical anaesthesia. Again it should be noted that any differences between groups observed were only a matter of 10–20 s, which is unlikely to be clinically relevant. However, ewes in these trials were held in a relatively small pen of 6 × 4 m, such that lambs only had to cross a short distance to find their dams. It is possible that these results could be magnified in a larger field.

Our results demonstrating significant wound anaesthesia within 1 min of the application of topical anaesthesia concur with previous findings that have noted that mulesing wounds treated with immediate postoperative topical anaesthesia are desensitised within 1–3 min of mulesing. As such, it would seem pain is unlikely to have impaired the times to mother up or to feed in lambs treated with topical anaesthesia.[13]

The results of wound sensitivity testing and behavioural observations in these trials are consistent with and extend our previous findings that topical anaesthesia for mulesing wounds is efficacious up to 8 h post-treatment.[13,15] The present study has confirmed anecdotal observations that wound anaesthesia persists up to 24 h post-mulesing. A significant and increasing hyperalgesic wound response was observed in mulesed, non-anaesthetised lambs over 24 h in both trials and this effect was significantly ameliorated by treatment with topical anaesthesia.

Our results do not concur so readily with previous findings by Paull et al,[15] who reported that pain-related behaviours in lambs treated with topical anaesthesia developed between 4 and 8 h post-mulesing. Our previous trials have revealed minimal evidence of wound pain or pain-related behaviour at 1, 4 or 8 h post-mulesing in lambs treated with Tri-Solfen[13] and we now report minimal evidence of pain-related behaviour at 24 h post-mulesing. This variation may be explained by differences in methodology. Videotape analysis of lamb behaviour was used in the Paull et al. trial,[15] which is likely to be more sensitive to abnormal behaviours than the NRS field observations used in our trials. However, it is also possible that methodology used by Paull et al.[15] trial resulted in exaggerated pain-related behavioural responses for the lambs. In that trial, lambs were held in small indoor pens and underwent repeated handling at 30 min and 6 h post-treatment for blood sampling, which may have heightened their stress responses and also exacerbated bleeding and pain from the wound because of the repeated physical disturbance. Our trials were designed to mimic the field situation such that lambs were returned to their dams and left undisturbed in a pasture-covered paddock between behavioural assessments. This may have reduced pain and pain-related behaviour in these lambs. It is important to note that Paull et al. found that lambs treated with a combination of topical anaesthetic and a non-steroidal antiinflammatory drug (NSAID) did not display a significant occurrence of pain-related behaviours in comparison with unmulesed controls between 4 and 12 h.[15] Thus the use of NSAIDs should be further explored and considered as an option for further reducing postoperative pain.

The technique of wound sensitivity testing over the first 8 h following mulesing with or without treatment with topical anaesthesia has been previously described.[13] The results from the present study indicate that treatment was still effective at 24 h post-mulesing using the same wound pain assessment techniques. Hypersensitivity to LT and pain stimulation evident within the wound and the surrounding areas in the first minute after mulesing in non-anaesthetised lambs was followed by increased allodynia and primary and secondary hyperalgesia at 24 h post-mulesing. There was evidence of significant and persistent wound anaesthesia at 24 h post-mulesing in lambs treated with topical anaesthesia.

Local anaesthetic agents act by inhibiting the generation and conduction of ionic fluxes required for the conduction of nerve impulses responsible for the sensation of pain. These anaesthetics are readily absorbed through mucous membranes and damaged skin to reach the nerve fibres. Tri-Solfen contains lidocaine hydrochloride (40.6 g/L) and bupivacaine hydrochloride (4.5 g/L) as the active anaesthetic agents and adrenaline tartrate (24.8 mg/L) as a vasoconstrictor. The half-life for lidocaine in humans is reported to be 1.5–2 h and that of bupivacaine is 2.7 h in adults and 8.1 h in neonates. When used topically, adrenaline would slow the rate of systemic absorption of the two anaesthetic agents and reduce wound haemorrhage. The reduced rate of systemic absorption keeps the active ingredients concentrated at the site and slows the metabolism of the agents, prolonging the intensity and duration of local anaesthesia.

Local anaesthetics can provide rapid and prolonged anaesthesia when applied to open wounds[19–25] and can also prevent or reduce the subsequent pain escalation response.[26–28] The vasoconstrictive properties of adrenaline slow the blood flow to the wound, thereby suppressing the inflammatory cascade, resulting in a reduction in associated pain caused by accumulation of inflammatory mediators, including cytokines and histamines.[29] This may provide an additional explanation for the prolonged efficacy of the combination topical anaesthesia/vasoconstrictor preparation.

Another hypothesis for the long-term efficacy of the topical anaesthesia is the presence of a barrier effect from inclusion of a gel base in the preparation. We previously found that mild pain alleviation was observed through the use of a placebo agent that consisted of the gel base without the local anaesthetic or vasoconstrictor actives.[13] This is also consistent with the findings of published studies on skin incisions and open wounds in humans, where barrier dressings have significant benefits for wound healing and pain attenuation by coating damaged nerve endings and providing a barrier against ongoing environmental exposure and tactile stimulation.[30–33]

Conclusion

The topical anaesthetic, antiseptic and haemostatic product Tri-Solfen® developed for pain alleviation at mulesing has a prolonged duration of action up to 24 h post-treatment. It is hypothesised that the combination of local anaesthesia, haemostatic and vasoconstrictor action of epinephrine with inhibition of the inflammatory cascade and the barrier effect of the gel base of the product may explain the finding of prolonged wound anaesthesia observed in the present study.

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BOOK REVIEW

Color atlas of veterinary histology. 3rd edn. Edited by WJ Bacha and LM Bacha. Wiley-Blackwell, West Sussex, 2012. 356 pages. Price A$125.00. ISBN 978 0470958513.

The 3rd edition of this hardcover text covers histology in the major veterinary species (dog, cat, horse, cow, sheep, goat, pig and chicken) and is designed as a learning tool for students.

The book begins with a brief introduction to histology, including tips for viewing slides and setting up a microscope. All tissues and systems are discussed chapter by chapter. There is a short introduction to each tissue or system, followed by annotated photomicrographs relevant to the appropriate species. All photomicrographs are in colour and diagrams are in black and white. The chapter on haematology is predominantly illustrated with blood smears rather than histological sections. It identifies the normal blood components for each species and mentions common variations seen on normal smears. The text concludes with a glossary and index.

The introductory chapter is short and succinct, but covers all that would be required by most veterinary students. Headings are consistent and easily recognised and the photomicrographs are well laid out. Boxes containing chapter summaries are not always clear at a glance, because of poor text formatting. Helpful hints, highlighted in blue boxes, are very useful and cover topics such as how to recognise certain tissues and suggestions for examining certain tissues and slides. The glossary may be useful for some, but the internet is likely to have made this section somewhat redundant.

Although most of the illustrations are of high quality, a proportion is not, particularly the larger pictures. The chapter on bone marrow is rudimentary and would not be of particular use to either students or pathologists as a reference.

This edition is slightly longer and the layout of the text improved and more user friendly, especially the headings, compared with the 2nd edition, but the content is essentially unchanged. Helpful hints and root word boxes are a useful addition. Most of the illustrations from the 2nd edition are included, with some new ones. The CD is new for the 3rd edition, but contains only the illustrations, which are viewed via an index or search function.

The text is illustrative rather than an in-depth description of tissue. Many of the medical histology books have such detailed analysis and briefly cover EM and cell cycles, topics that are not covered in this atlas. However, I love the extensive coverage of species-specific variations, which obviously cannot be found in a medical histology text.

The text would be helpful to students studying veterinary histology and as a reference for both veterinarians in practice and veterinary pathologists.

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