Topical anaesthesia alleviates short-term pain of castration and tail docking in lambs

S Lomax,[a] H Dickson,[a] M Sheil[a,b] and PA Windsor[a]*

Objective To investigate the effect of a topical anaesthetic formulation on pain alleviation, wound healing and systemic levels of local anaesthetic actives in lambs undergoing castration and tail docking.

Design Three placebo-controlled and/or randomised experiments were conducted using three groups of Merino lambs (n = 62, 68 and 19) undergoing routine castration and tail docking.

Procedure Surgical castration, with either surgical or hot-iron tail docking, was performed with and without the application of topical anaesthetic (Tri-Solfen®) or placebo. The effects of this procedure were compared with those of rubber ring castration and tail docking, and of the handled but unmarked controls. Wound pain was assessed using calibrated Von-Frey monofilaments over a 4-h period, pain-related behaviour was assessed over 5 h, wound healing was assessed at 14 and 28 days, and the plasma levels of lignocaine and bupivacaine were determined.

Results Rapid and up to 4 h primary hyperalgesia developed following surgical castration and tail docking in the untreated and placebo-treated lambs. It was absent in the castration wounds, and significantly reduced in the tail-docking wounds, of the treated lambs. Hot-iron docking was associated with mild and transient secondary hyperalgesia, which was abolished by the topical anaesthesia. There was a significant reduction in pain-related behaviours in treated lambs, which were not significantly different in their behaviour to the sham-operation handled controls. Plasma lignocaine and bupivacaine levels were below the toxic thresholds in all tested lambs.

Conclusion Topical anaesthesia alleviates wound pain and significantly reduces pain-related behaviours in lambs undergoing surgical castration plus surgical or hot-iron tail docking, without a negative effect on wound healing or a risk of systemic toxicity.

Keywords analgesia; castration; lambs; pain; tail docking; topical anaesthesia; welfare

Abbreviations HI, hot iron; LT, light touch sensation; NRS, numerical rating scale; P, pain sensation

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Lamb marking, which includes castration of male lambs and tail docking of male and female lambs is a routine husbandry procedures performed annually on between 31 and 34 million lambs in Australia,[1] and many more throughout the world. Although these procedures cause acute pain and stress,[2–7] they are routinely conducted without analgesia. Despite their justification for animal health, production and management reasons, there is growing concern for the welfare of animals undergoing these procedures. In the European Union, for example, some countries have passed legislation banning piglet or lamb castration unless analgesia is used. In other countries, supermarket chains are refusing to take products from pigs unless they were castrated with analgesia. In the United Kingdom, the Farm Animal Welfare Council has released a new report calling for urgent action to develop effective analgesia for lambs undergoing castration and tail docking.[8] These developments reflect the growing demand for humane management of livestock throughout the world and set a challenge to develop effective methods of pain alleviation that are practical and applicable to farming operations. Tri-Solfen® (Bayer Animal Health, Gordon, NSW, Australia) is a 'farmer applied' spray-on topical anaesthetic formulation of lignocaine (as the hydrochloride: 40.6 g/L), bupivacaine (as the hydrochloride: 4.5 g/L), adrenalin (as a tartrate: 24.8 mg/L) and cetrimide (5.0 g/L in a gel base). It has been reported that topical anaesthesia with Tri-Solfen is highly effective in alleviating pain associated with mulesing and improves wound healing.[9] In the present studies we investigated the potential for topical anaesthesia to alleviate the pain associated with castration and tail docking in sheep.

Materials and methods

Two experiments were performed on ram lambs undergoing routine tail docking and castration in commercial flocks in the Central Tablelands and Southern Highlands of New South Wales, Australia. Lambs were aged 6 to 12 weeks with a mean initial body weight of 14.48 kg (±2.8 kg) and consisted of 62 F1 Merino × South African Mutton Merino lambs (Central Tablelands flock) and 68 finewool Merino lambs (Southern Highlands flock) born in the winter of 2007. Lambs were divided into eight treatment groups to examine surgical castration plus surgical or hot-iron (HI) tail docking, (performed without Tri-Solfen or with Tri-Solfen or placebo), rubber ring castration and tail docking, and sham procedure in which lambs were handled only but remained uncastrated or tail-docked (Table 1). In a third experiment, for determining the plasma levels of lignocaine and bupivacaine after treatment with the topical anaesthetic, blood samples were collected from finewool Merino lambs aged 6 to 12 weeks from a commercial flock in the Southern Highlands, NSW, undergoing routine tail docking and castration (n = 15) or mulesing, tail docking and castration (n = 4).

General management and marking

On the day of each experiment lambs from each flock were yarded and drafted into a holding yard. They were then selected at random, weighed, ear-tagged and placed in marking cradles. In experiments 1

*Correspondence author.
[a]Faculty of Veterinary Science, University of Sydney, PMB 3, Camden, New South Wales 2570, Australia; pwindsor@camden.usyd.edu.au
[b]Animal Ethics Pty Ltd, Yarra Glen, Victoria, Australia

Table 1. Treatment groups and total numbers of lambs in each group in experiments 1 and 2

Group	Castration method	Tail-docking method	Treatment	Direct wound sensory assessment (n)	Pain-related behaviour assessment (n)
1	Knife	Knife	Untreated	11	11
2	Knife	Knife	Tri-Solfen	11	11
3	Knife	Knife	Placebo	11	11
4	Knife	Hot iron	Untreated	8	8
5	Knife	Hot iron	Tri-Solfen	8	8
6	Knife	Hot iron	Placebo	8	0
7	Rubber ring	Rubber ring	Untreated	0	12
8	Control	Control	Untreated	0	12

and 2, lambs were allocated sequentially to the treatment groups listed in Table 1, but the order of treatments was reversed in experiment 2.

Method of surgical castration and topical anaesthetic or placebo application

Surgical castration was performed using a clean, sharp surgical knife. The distal skin of the scrotum was excised, exposing the testes, which were individually extracted from the scrotum by traction, exposing the spermatic cord. Each testis was removed by incising the spermatic cord approximately 10 cm proximal to the head of the epididymis. In groups receiving topical anaesthetic or placebo treatment, Tri-Solfen or placebo gel (which consisted of the base gel without local anaesthetic or vasoconstrictor compounds) was applied to each of the exposed spermatic cords proximal to the site of incision, prior to removal of the testis, by inserting the nozzle of the spray gun along the length of the cord as far into the scrotal wound as possible and applying 1.5 mL of the Tri-Solfen or placebo to liberally coat the spermatic cord as the applicator was withdrawn. An additional 1.5 mL of Tri-Solfen or placebo was applied to the cut edge of the skin wound and the scrotal sac. The technique ensured that both the cord tissue that retracted into the wound after removal of the testis and the skin of the scrotal wound were well coated with the anaesthetic or placebo agent.

Method of surgical and HI tail docking

Surgical tail docking was performed using a cleaned, sharpened surgical lamb-marking knife, incising at the recommended position between coccygeal vertebrae 2 and 3.

The HI technique for tail docking used 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 severed.

Method of rubber ring castration and tail docking

Details of all procedural and treatment strategies are shown in Table 1.

Ring castration involved the application of an elastrator rubber ring around the neck of the scrotum proximal to the testes in order to obstruct blood flow to the testes and cause ischaemic necrosis. A second elastrator ring was applied to the tail at the recommended position between coccygeal vertebrae 2 and 3.

The first 35 to 38 lambs on each property on the day of the experiment were assigned to behavioural observations. They were allocated to a treatment group, treated accordingly, then were transferred in their treatment groups to 5-m^2 outdoor pastured observation yards away from visual and auditory stimuli. Pain-related behaviour assessments were performed by a trained observer, who was unaware of the treatment group strategy, using a numerical rating scale (NRS) at 5 and 30 min and 1, 2, 3, 4 and 5 h after the procedures.

The next 27 to 30 lambs on the day of the experiment were allocated to wound pain assessments. They were assigned to treatment groups and prior to castration and tail docking their responses to light touch (LT) and pain (P) stimulation of the intact skin on the scrotum and tail was assessed using Von-Frey monofilaments as previously described.[9] After castration and docking, (with or without Tri-Solfen or placebo application), lambs remained in the cradle for 1 min and their responses to LT and P stimulation of the tail and scrotal wounds were assessed by two observers who were unaware which treatment strategy (Tri-Solfen or placebo) had been used. Lambs were then transferred to a small holding yard in a mixed treatment group and returned to the lamb cradle for repeat assessments at 2 and 4 h following the procedures. After completion of assessments, lambs were returned to their dams at pasture.

Wound healing was assessed at 2 and 4 weeks. Lambs were re-yarded, weighed and placed in the cradle where their wounds were inspected and palpated by a registered specialist veterinarian (pathobiology).

Assessment of pain-related behaviour

Pain-related behaviour was assessed using the NRS developed previously[9] and modified by a combination of field observations and published reports of behavioural changes in response to castration and/or tail docking.[6–11] A trained observer (animal scientist blinded to treatment) observed the lambs at various time points after marking. Individual lambs were given a score between 0 and 3: 0 = no pain-related behaviour; 1 = mildly abnormal 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 = moderately abnormal 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 = displaying severely abnormal 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.

Direct wound sensory assessment

Von-Frey monofilaments are calibrated to bend at predetermined pressures to provide repeatable LT (10N) or P (75N) stimulation, as previously described.[9] They were used to perform direct sensory testing at seven predetermined sites on the cut skin edge of the scrotal and tail wounds and at four sites on the intact skin surrounding the wounds to determine the lambs' responses to LT and P stimulation before and up to 4 h after castration and tail docking.

Evidence of local anaesthesia (diminished response to LT and P stimulation), allodynia (heightened response to LT stimuli) and/or primary and secondary hyperalgesia (heightened response to P stimulus directly in the damaged tissue or in surrounding undamaged tissue, respectively) was assessed at each site. Responses were scored by monitoring induced involuntary motor reflexes in the rump and head, which were graded by vigour. Rump response scores were graded as: 0 = no response; 1 = minor involuntary motor responses 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 or 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 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 24 for peri-wound sensitivity and out of 42 for direct wound sensitivity.

Plasma lignocaine and bupivacaine analyses

In experiment 3, lambs were selected at random, placed in the cradle and 10 mL of blood was collected via direct jugular venous puncture. Lambs were then surgically castrated and tail-docked. Four lambs also underwent mulesing by an accredited practitioner using the industry standard technique. All wounds were treated with Tri-Solfen according to label recommendations or as outlined earlier. The lambs were then transferred to holding pens and blood samples were collected by repeat jugular venous puncture at 30, 90 and 120 min following the procedure, after which they were returned to their dams at pasture.

The blood samples were centrifuged, the plasma was frozen and then transferred to Agrisearch Analytical® (Rozelle, NSW) for analysis. Lignocaine and bupivacaine levels were determined using reverse-phase high-performance liquid chromatography with tandem mass spectrometric detection.

Statistical analysis

Data were analysed using SPSS version 14.0® (SPSS Inc., Chicago, IL, USA), and Genstat® version 10.0 (VSN International, UK 2007). Box-plots were examined and one-way analysis of variance was used to measure the short-term effects of treatment groups for which there was variation. Residual maximum likelihood estimation linear mixed models analyses were used to analyse NRS scores from behavioural and sensitivity-testing observations. Post-hoc pair-wise comparisons were performed for analyses in which the between group comparison was significant. For all statistical calculations, $P < 0.005$ was considered statistically significant.

This research program was approved by the Animal Ethics Committee of the University of Sydney and conformed to the provisions of the Declaration of Helsinki (2000).

Results

Weather conditions

During experiment 1 the weather was cool and overcast, with an average temperature of 13°C, during experiment 2 it was cool and fine, with an average temperature of 10°C and no fly activity and for experiment 3 it was warm and dry at 19°C, with moderate fly activity.

Morbidity, mortality and wound inspection

Clinical signs of tetanus were not observed and none of the lambs died. Direct inspection and wound palpation identified 3 lambs with abscess formation in the scrotal sac and 13 lambs with increased firmness and thickening of the cord, interpreted as a subacute to chronic inflammatory or scirrhous cord reaction at 14 days after the surgical procedure. There was no significant difference in abscess formation and scirrhous cord reaction according to treatment. Even at 4 weeks the majority of the lambs treated with rubber rings still had their scrotums and tails attached, although the tissues were cold, shrunken and firm, indicative of ischaemic necrosis. In many cases there was reddening and swelling of the skin immediately proximal to the ring, accompanied by a small amount of yellow to greenish exudate, suggesting focal inflammation and minor infection.

Direct sensory testing of the castration wound and surrounding skin

Before surgical castration. There was little response to LT or P stimulation of the intact skin of the scrotal area prior to castration. Mean response from the four testing sites (maximum possible score 24) was $\leq 0.44 \pm 1.04$ for LT and $\leq 1.03 \pm 1.6$ for P. There were no significant differences between groups within each trial.

After surgical castration. There was a significant elevation in the response to P stimulation of the wound over time ($P < 0.0001$), with a significant treatment effect ($P < 0.0001$). Primary hyperalgesia developed within 1 min of castration in the untreated and placebo-treated lambs, but not in the Tri-Solfen-treated lambs. Response scores in the Tri-Solfen-treated lambs were significantly below those of the untreated and placebo-treated lambs at all time points post procedure ($P \leq 0.002$) (Figure 1). Response to P stimulation of the skin surrounding the castration wound did not change over time in the group as a whole. Response scores were significantly lower in the Tri-Solfen-treated lambs than in untreated and placebo-treated lambs at 1 min ($P = 0.005$) and 4 h ($P = 0.02$) (Figure 2).

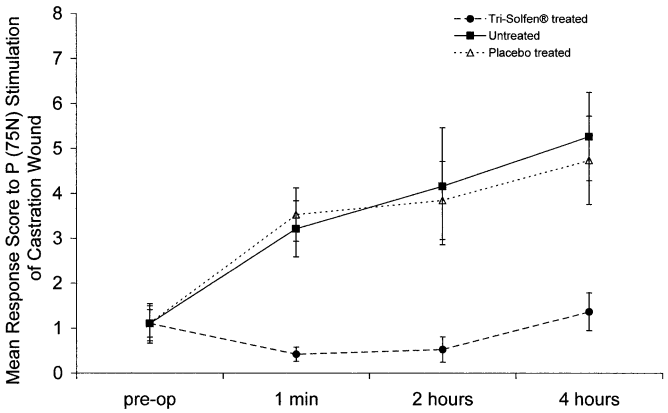

Figure 1. Mean pain (P) response scores of lambs following stimulation of the surgical castration wound comparing untreated, placebo only and topical anaesthesia treatments.

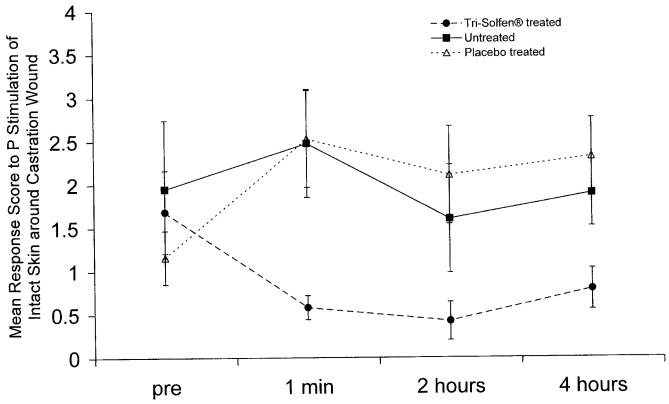

Figure 2. Mean response to pain (P) stimulation of the skin surrounding the castration wound comparing untreated, placebo only and topical anaesthesia treatments.

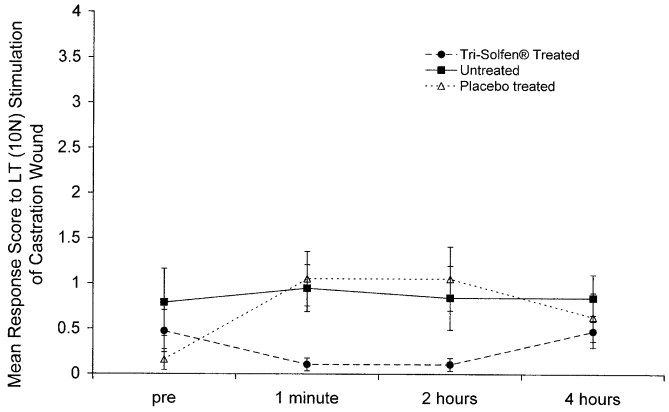

Figure 3. Mean response to light touch (LT) stimulation of the castration wound comparing untreated, placebo only and topical anaesthesia treatments.

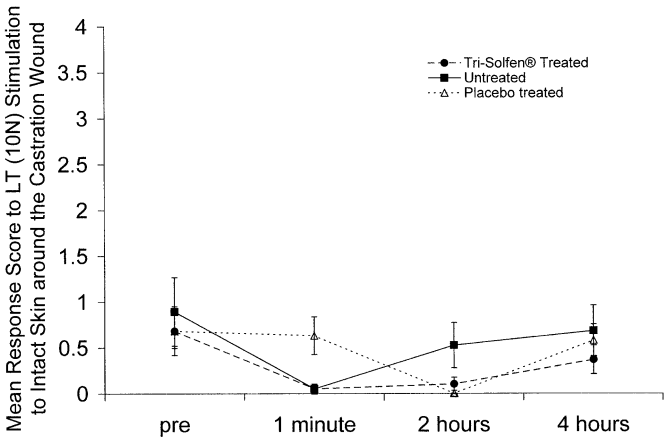

Figure 4. Response to light touch (LT) stimulation of the skin surrounding the castration wound.

Response to LT stimulation of the castration wound. There was no significant overall change in the response to LT over time. However, there was a significant treatment effect (P = 0.008), with LT responses of the Tri-Solfen-treated lambs significantly less than those of the untreated lambs at 1 min (P = 0.003) and 2 h (P = 0.05). Placebo-treated lambs were not significantly different to untreated lambs (Figure 3). There appeared to be a mild decrease in the response to LT stimulation of the skin surrounding the castration wound between before treatment and 1 min after in both untreated and Tri-Solfen-treated lambs, but not in placebo-treated lambs, and there was a mild increase in the response to LT stimulation of the skin surrounding the castration wound between 1 min and 2 h afters in the untreated, but not in the placebo- or Tri-Solfen-treated, lambs (P = 0.001) (Figure 4).

Direct sensory testing of the tail-docking wound and surrounding skin

There was a significant change in the response to P over time (P < 0.0001), with significant treatment effect. Lambs docked with a HI had response scores significantly below those of the surgically docked lambs (P < 0.0001).

Surgically tail-docked lambs. There was evidence of primary hyperalgesia, with a significant elevation in response to P stimulation between 1 min and 2 h (P < 0.0001). There was a significant treatment effect (P = 0.034): Tri-Solfen-treated lambs had P response scores that were less than those of the untreated lambs at all time points (P = 0.008 at 4 h). The P response scores for the placebo-treated and untreated lambs were not significantly different (Figure 5). There was no significant change over time to P stimulation around the wound. However, there was a significant treatment effect (P = 0.018), with Tri-Solfen-treated lambs displaying response scores below those of untreated lambs at all time points, which was statistically significant at 4 h (P = 0.005) (Figure 6).

HI tail-docked lambs. There was no evidence of primary hyperalgesia and no significant treatment effect. However, the P response scores were significantly lower at the 4-h time point in the treated lambs compared with the untreated (P = 0.03) and placebo-treated lambs (P = 0.008) (Figure 5). There was evidence of early secondary hyperalgesia, with a mild but significant change over time in response to P stimulation around the wound (P = 0.02), within 1 min of HI

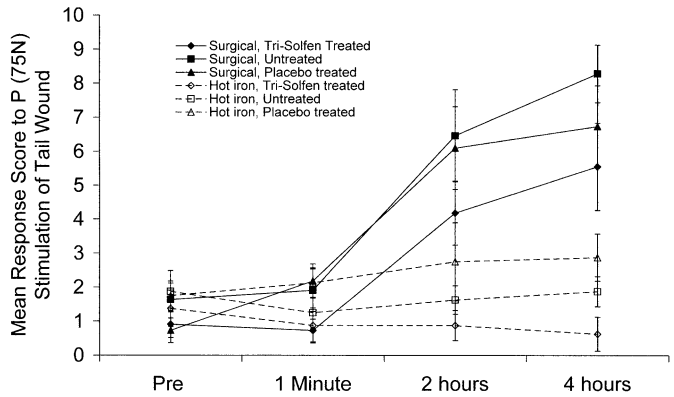

Figure 5. Mean response to pain (P) stimulation of the tail wound over time comparing 6 different treatment groups of lambs.

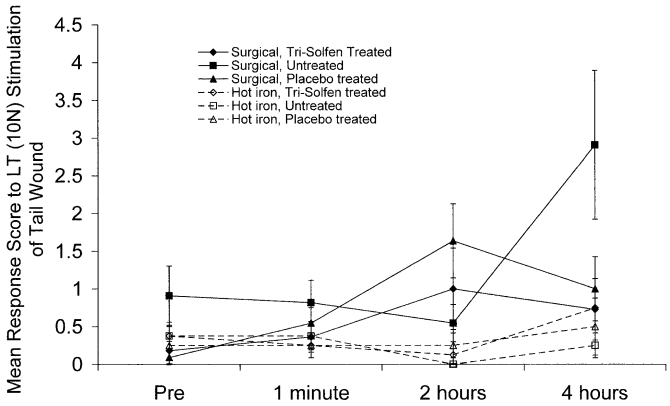

Figure 7. Mean response to light touch (LT) stimulation of the tail wound over time comparing 6 different treatment groups of lambs.

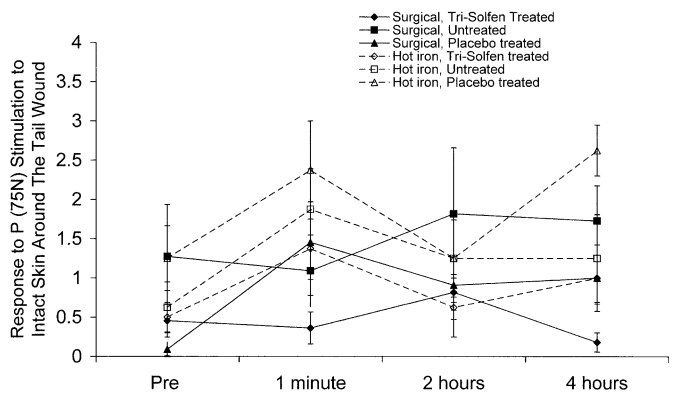

Figure 6. Mean response to pain (P) stimulation around the tail wound over time comparing 6 different treatment groups of lambs.

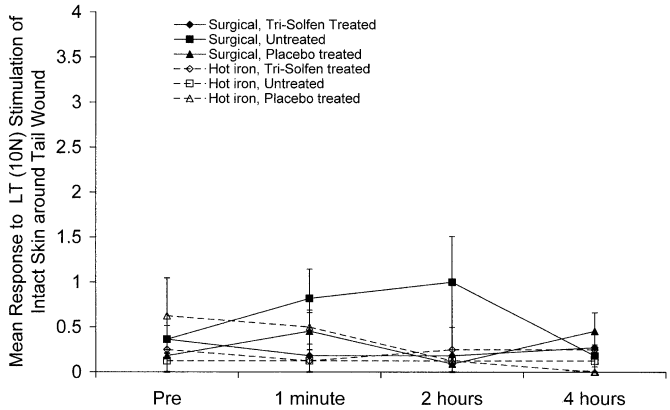

Figure 8. Mean response to light touch (LT) stimulation of the skin surrounding the tail wound over time comparing 6 different treatment groups of lambs.

docking and most prominent in the untreated and placebo-treated lambs (Figure 6).

Response to LT stimulation of the tail-docking wound. There was a significant increase in LT response scores over time ($P = 0.01$) with a significant treatment effect ($P = 0.009$). The greatest increase in response occurred between the 2- and 4-h time points in surgically docked, untreated lambs ($P = 0.01$), which was not apparent in surgically docked Tri-Solfen-treated lambs or those that were docked with a HI. Placebo-treated surgically docked lambs displayed intermediate values (Figure 7). There was minimal response to LT stimulation of skin surrounding the wound in all treatment groups (Figure 8).

Pain-related behaviour

There was a significant change in lamb behaviours over time ($P < 0.001$), with lambs exhibiting the greatest abnormalities in posture, gait or behaviour within the first 4 h after marking. Treatment type was shown to be highly significant ($P < 0.001$), with ring-castrated lambs displaying significantly higher pain-related behaviour scores than the lambs in the surgical knife and HI treatment groups. Lambs treated with topical anaesthesia displayed significantly less pain-related behaviours than the untreated, ring-castrated and placebo-treated lambs ($P < 0.001$) and were not significantly different from the handled controls (Figure 9).

Plasma lignocaine and bupivacaine analyses

Mean plasma lignocaine levels were 0.17 (±0.09), 0.12 (±0.06) and 0.1 (±0.06)mg/L at 30, 90 and 120 min post treatment, respectively. The maximum recorded level at any time point in any of the lambs was 0.39 mg/L at 30 min post treatment.

Mean plasma bupivacaine levels were below the level of detection (<0.0025 mg/L) or quantification (<0.01 mg/L) in 5 lambs, with a mean value ±SD of 0.014 ± 0.003 mg/L in the remaining lambs at 30 min after treatment. Thereafter, bupivacaine levels at 90 and 120 min were either at or below the level of quantification in 10 lambs, with 0.013 ± 0.003 mg/L in the remaining animals.

Discussion

There are rapidly emerging commercial and ethical imperatives to find practical methods of alleviating the pain and stress inflicted on farm animals during routine husbandry procedures such as castration and tail docking. Our study presents evidence that alleviation of pain

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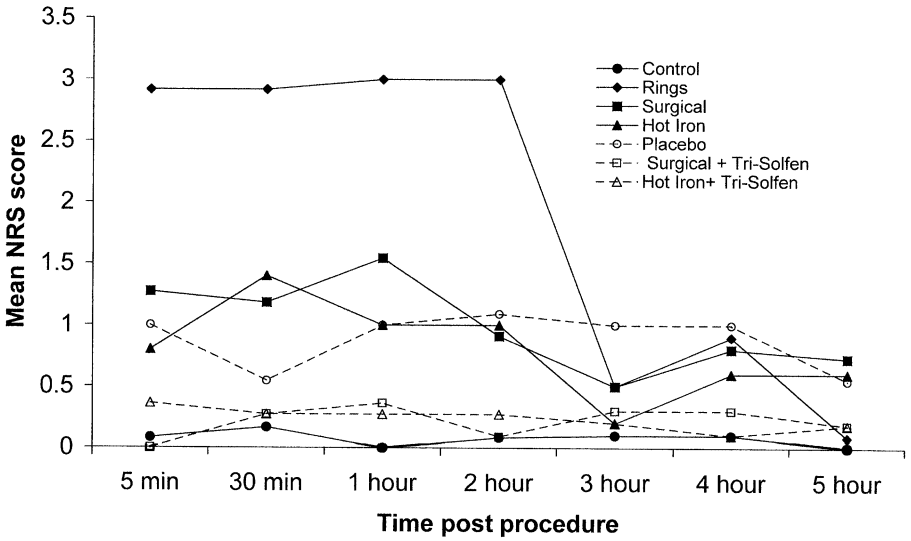

Figure 9. Mean scores for pain-related behaviour of 6 different treatment groups of lambs compared with control lambs, using a numerical rating scale.

up to 4 h is achieved for lambs undergoing surgical castration plus surgical or HI tail docking using a farmer-applied, spray-on topical anaesthetic formulation. This finding has major welfare implications for all livestock undergoing such procedures.

Local anaesthetic agents, such as lignocaine, when injected are highly effective in alleviating the pain associated with castration and tail docking,[2,12–14] and the safety and efficacy profiles of local anaesthetic agents are well described in sheep.[15–18] Despite this, local anaesthetic injections are rarely used during routine husbandry procedures because of the practical and economic constraints. Topical anaesthesia, applied during and/or immediately after the procedure, offers a practical alternative that may still be highly effective for surgical procedures.

Local anaesthetic agents act directly on nerve tissue to elicit a reversible block of the conduction of signals responsible for the sensation of pain. When applied to open wounds they can effect rapid and profound local anaesthesia.[9,19–24] They can also prevent or reduce the subsequent pain escalation response.[25–27] Although it may seem counterintuitive to apply local anaesthetic after a procedure, there are significant advantages to this approach in the sheep farm setting. Firstly, for economic reasons, on-farm surgical procedures are performed very quickly, taking a matter of seconds; the pain involved may well be less than that of a local anaesthetic injection, particularly if a well-sharpened blade is used for the procedure. Secondly, by not having to wait for the anaesthetic agent to take effect before performing the procedure, double-handling of the lamb is avoided and it is promptly returned to its dam, minimising the stress of handling and separation. Thirdly, the agents can be applied by the farmer, without direct veterinary intervention. Further, postoperative pain may be more effectively addressed as the actives are delivered directly to the traumatised nerve fibres and tissues that are the source of pain, and can be delivered in formulations designed for maximal adhesion and duration of effect. Finally, the anaesthetic agents can also be delivered in combinations with other agents, such as vasoconstrictors and antiseptics, with possible synergistic and adjunctive wound care effects.

Our studies of topical anaesthesia for livestock husbandry have used Tri-Solfen because the lignocaine, bupivacaine and adrenalin in the delivered doses have proven effective for anaesthesia and haemostasis of open wounds in human patients,[19–24] and because it contains a viscous gel base that can be sprayed onto and adheres to open wounds. Previous studies have demonstrated that topical anaesthesia is highly effective in alleviating the pain and improving the healing of mulesing wounds in sheep, with lower acute cortisol responses and reduced wound pain and pain-related behaviour for up to and including 8 h afterward.[9,28] Our current results extend these findings by documenting that topical anaesthesia is also highly effective in alleviating the pain associated with surgical castration plus surgical or HI tail docking.

It can be difficult to quantify pain in animals and most authors use a combination of techniques. We elected to use behavioural analysis together with direct sensory testing. Quantitative sensory testing is a widely used, validated technique,[29–32] which we have previously used in lambs to record the onset, evolution and distribution of pain from mulesing wounds and their response to a topical local anaesthetic.[9] Our current findings of alleviation of wound pain and prevention of primary and secondary hyperalgesia in the first minute and up to 4 h after surgical castration in Tri-Solfen-treated lambs is supported by finding that pain-related behaviour was also significantly reduced in the Tri-Solfen-treated lambs.

We found little evidence of direct wound pain after HI tail docking, as identified in previous studies.[6,10,11] The HI is believed to cauterise and destroy the nervous sensory tissue in the tail, resulting in a subsequent loss of sensation.[6,33,34] Mild and transient secondary hyperalgesia developed in the surrounding tissues, but was prevented by treatment with Tri-Solfen. We did not find any evidence of delayed wound healing in the HI docked lambs, with or without treatment.

Surgical tail docking resulted in less immediate secondary hyperalgesia. However, there was escalating primary allodynia and primary and secondary hyperalgesia over the ensuing 4 h, consistent with the pain escalation phenomenon. A significant, but incomplete, analgesic effect was apparent with the use of Tri-Solfen and it was considered that

arterial bleeding from the tail may have diluted the anaesthetic agent and prevented it from adhering effectively to the cut skin edges of the tail wound. Nevertheless, the use of analgesia was still associated with a significant reduction in pain-related behaviour.

Blood plasma lignocaine and bupivacaine levels were well below the toxic threshold of 6 mg/L (humans) and the toxic convulsive plasma level of 40 mg/L in sheep. Wound healing was unimpaired and we conclude that application of Tri-Solfen at the recommended rate to lamb marking wounds will not be detrimental to their health.

Rubber ring castration and tail docking is widely used because of its ease and practicality. It is less amenable to pain alleviation with topical anaesthesia because of the poor skin penetrability of local anaesthetic agents. We included a rubber ring treatment group for behavioural comparison, as many consider this to be the most humane method of castration and docking. However, that opinion is not supported by our results. Lambs undergoing ring castration and docking in our trials exhibited agitation, bleating, lateral and ventral recumbency, lip curling, kneeling, knee walking, writhing and other abnormal postures indicative of 'intense pain' and 'marked distress'. These behaviours persisted beyond 2 h after application of the rings and is consistent with previous reports.[3,13] The nature of their distress 'dominated their experience'[35] and rendered them oblivious to external environmental stimulation, to the extent that they were unsuitable for direct wound sensory testing. Our results concur with Grant,[6] who determined a hierarchy of pain associated with different marking methods, with rubber ring castration and tail docking being the most painful (and ear tagging as the least most painful intervention), and noted that 'All treatments involving the use of tight rubber rings resulted in significant abnormal posture and active pain behaviour displays.'

Arguments that rubber rings cause less pain and stress are generally based on interpretation of biochemical measurements, with greater elevation and persistence of the cortisol response following surgical procedures. However, is it appropriate to compare surgical and non-surgical procedures using the cortisol response as a measure of pain? Surgical wounding (breaching the skin) prompts a unique physiological response that is designed to maintain blood volume and institute body defences and wound healing. Cortisol secretion is an important part of this physiological response,[36] which occurs even in the complete absence of pain, such as when patients are unconscious and/or under full general anaesthesia.[37–40] A more protracted cortisol response following surgical castration does not necessarily indicate greater or more protracted pain compared with rubber ring castration. It may simply indicate that there has been a greater breach of the skin.

Our results indicate that castration and tail docking in lambs can be achieved with minimal pain and distress using surgical castration, HI tail docking and intra-/postoperatively applied topical anaesthetic. This technique offers the sheep industry a welfare-appropriate alternative to both the currently used methods: surgery without analgesia and rubber rings. In our opinion, investigations of other methods of analgesia are required to address the considerable welfare concerns that occur with the routine use of rubber rings for castration only or for combined castration and tail docking.

Tri-Solfen is currently only available under a restricted use permit through veterinarians for use in alleviating post-mulesing pain in lambs in Australia. However, the use of topical anaesthetic formulations has the potential to provide a practical and economic means of reducing the pain associated with castration and tail docking and improve the welfare of millions of young lambs annually, both in Australia and internationally. Investigations as to whether it is similarly effective in cattle and pigs have commenced.

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BOOK REVIEW

Where to see birds in Victoria. Edited by Tim Dolby, Penny Johns and Sally Symonds. Published for Birds Australia by Jacana Books, Allen and Unwin, NSW, Australia, 2009. 192 pages. AUD$35.00. ISBN 978 1 74175 736 1.

The book is published to assist people find the special birds of Victoria which from the photographs mean visiting very beautiful places across Victoria. Victoria is divided into 8 regions making it easier to identify one of the 43 places to go and see interesting native birds near you are located. Places, as close as 4 km to the Melbourne GPO, are reliable sites for seeing a wide variety of birds in habitat ranging from forests, wetlands, open woodlands to grasslands. The book outlines the best season in which to see the birds at each of the 43 locations.

Being a Birds Australia publication, the book is supported by regular surveys of bird populations recorded by enthusiast members making the likelihood of seeing the described species highly likely. The book also contains an annotated list of bird species and where the less common species will be likely observed in the wild. A comprehensive index provides for easy searching.

Pictures of the general habitat and some birds likely to be seen at each location are included and are of excellent quality. The book is of a size suitable for hand carriage while bird spotting and keeping in the glove box of the car ready for another twitching session.

Andrew Turner
Princes Hill Victoria.

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