Short Communication

Local anesthetic delivered with a dual action ring and injection applicator Numnuts® reduces the acute pain response of lambs during tail docking.

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Simple Summary: Tail docking is a procedure practiced on millions of lambs all over the world. The objective is to prevent fecal soiling on the lower part of the tail, reduce soiling of the breech and thereby lessen the risk of blowfly strike. Docking can be done with a knife or a clamp, but applying a latex ring round the tail, cutting off the blood supply so that the tail drops off a few weeks later, is the most popular method. All methods cause acute pain which diminishes substantially after the first hour. The present trial determined whether local anesthetic delivered by a prototype Numnuts® device, a novel, dual-function applicator, would reduce this pain. Each lamb was restrained in a cradle and the dual function device was used to fit the tail with a ring and inject lignocaine at the constriction site. Control lambs received rings without anesthetic, and a third sham control group was handled in the cradle but did not receive rings or anesthetic. All lambs were returned to their pen with their mothers and videoed for three hours for behavioral signs of pain. Every 5 minutes for the first hour and then every ten minutes each lamb's posture, movement and feeding behavior was classified and quantified and the data subjected to statistical analysis. It was concluded that applying lignocaine using the novel device greatly reduced the degree of pain observed.

Abstract: Docking the tail of lambs is a standard husbandry procedure and is achieved through several techniques including clamps, hot or cold knives and latex rings, the last of which is the most popular. All tail docking methods cause acute pain which can be reduced by application of local anesthetic, however precise anatomical injection for optimal efficacy requires considerable skill. This pen trial evaluated the ability of local anesthetic delivered with a dual function ring applicator / injector to alleviate acute tail docking pain. Thirty ewe lambs were assigned to one of three treatment groups (n = 10 per group): ring plus local anesthetic (Ring LA), ring only (Ring) and sham handled control (Sham). Lambs were videoed and behavior categorized every 5 minutes for the first hour and every 10 min for the subsequent 2 hours after treatment. There was a significant effect ($p < 0.001$) of treatment on total active pain related behaviors in the first hour, with Ring lambs showing higher counts compared to Ring LA or Sham. Ring lambs also displayed a significantly higher count of combined abnormal postures ($p < 0.001$) than Ring LA or Sham lambs. Delivery of 1.5ml of 2% lignocaine via the dual action device abolished abnormal behaviors and signs of pain in Ring LA lambs. However, lambs in the Ring LA group spent less time attempting to suckle compared to Ring and Sham lambs, suggesting that some residual discomfort remained.

Keywords: analgesia; sheep; ischemia; latex ring; rubber ring; de-tailing; behavior.

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1. Introduction

Docking the tails of lambs by applying a vasoconstrictive latex rubber ring is a widespread practice used in many countries. The procedure causes acute pain and stress that lasts for over an hour [1-3]. Trials have shown that when local anesthetic (LA) is injected into the tail prior to the ring being applied, pain can be greatly alleviated [1]. The vast majority of farmers would prefer to cause as little pain as possible when docking their animals [4], however injection of LA is slow, and cumbersome and requires considerable technical skill for accurate location of the injection [5]. To administer LA and a rubber ring currently requires two tools: a syringe and needle to inject LA, and a set of marking pliers to fit a ring on the tail. Furthermore, injection with a syringe and needle risks needle stick injury. It is therefore unsurprising that very few commercial-scale farmers use local anesthetic for tail docking.

To address these issues of logistics, ergonomics and operator safety, a novel dual function marking instrument (Numnuts®) was developed by Senesino Ltd, (Glasgow, UK), that allows the operator to fit a latex docking ring around a lamb's tail and then inject local anesthetic into the tail adjacent to the ring. The Numnuts® device provides accurate and consistent local anesthetic application without a requirement for detailed knowledge of animal anatomy or extensive operator training. The trial described here examined the degree of pain relief provided by docking the tail of lambs using a late-stage prototype of the Numnuts® device.

2. Materials and Methods

2.1. The applicator device

A protype version of a novel dual-function marking tool was developed. The device allows the operator to rapidly fit a rubber ring around a lamb's tail and then inject 1.5ml of local anesthetic past the ring into the tail, just cranial (proximal) to the constriction site. When the rubber ring contracts over the tail, it temporarily holds the prongs of the device in a fixed position around the tail. This temporary fixation enables the injection mechanism to consistently deliver a metered 1.5 mL volume of local anesthetic subcutaneously into the tissues of the tail beneath the ring.

2.2. Design of the efficacy trial

The efficacy of local anesthetic (1.5mL 2% lignocaine hydrochloride, Troy laboratories, Australia) injected using a late stage prototype of the Numnuts® applicator (Senesino Ltd, Glasgow, UK) was examined in 2 to 4-week old, Greyface cross Texel ewe lambs. Thirty lambs (5.8-11.8 kg) were assigned to three treatment groups (n=10 per group): ring plus local anesthetic (Ring LA), ring only (Ring) and sham handled control (Sham). Groups were balanced by stratified randomization on weight.

Lambs were individually identified by large colored numerals sprayed on their flanks. The lambs were housed as ewe-lamb pairs in group pens (8x5m) with deep straw bedding over concrete floors at the Moredun Research Institute, Bush Loan, Edinburgh, Scotland (Figure 1). Pens housed 7-10 lambs each. Activity in each pen was recorded by two video cameras connected to digital video recorders positioned on opposite sides of the pen, and footage captured by a video management software (Huawei Technologies Co., Ltd, Reading, UK).

During treatment application, lambs were restrained in dorsal recumbency in a marking cradle. Ring lambs had rubber rings (Elastrator Brand) applied using the prototype applicator without an injection, Ring LA received an injection of 1.5 mL lignocaine via the prototype applicator at the time of ring application. Sham controls had their tail manipulated without application of a ring or injection. After the procedure, the lambs were returned to their pens, with each pen containing a mix of treatment groups.

Figure 1. Housing facilities for the trial. Lambs were restrained in a cradle and the prototype device was used to fit the tail with a ring and inject lignocaine at the constriction site. Lambs were then returned their mothers in concrete-floored pens with deep straw bedding.

2.3. Capturing and classifying the pain responses

The responses of the lambs were videoed for analysis of active pain avoidance behaviors. Personnel quantifying the behaviors were blinded for treatment group. Postures were classified and scored at 5-minute intervals for the first hour and at 10-minute intervals for the second and third hours, as shown in Table 1. Active pain related behaviors were classified every 5 minutes for the first hour and were summed to give a total count. Teat seeking behavior was also classified during the scoring of active behaviors (Table 1).

Table 1. Descriptions of behaviors recorded during the experiment.

Behavior	**Abbreviation**	**Description**
Active pain avoidance		
Restlessness	Rst	Transition from standing to lying or vice versa within a 30 second window at the observation timepoint
Kicking/foot stamping	FSK	Either a front or hind limb (usually hind limb) was lifted and forcefully placed on the ground while standing or was used to kick while standing or lying
Rolling	rl	Lamb rolled from lying on one side to the other without getting up or rolled on its back and then returned to lying on the same side.
Jumping	jmp	Lamb moved forward using bunny hops with its hind limbs
Licking/biting wound site	LBW	Movement of the head beyond the shoulder, including both looking and touching at the source of pain and grooming.
Easing quarters	EQ	Abnormally lowers rear quarters (standing) or attempts to keep quarters off the ground (lying).
Teat seeking	TS	No differentiation with or without sucking
Pain behaviors	Rst+FSK+rl+jmp+ LBW+EQ	All pain avoidance behaviors pooled
Postural behaviors		

Normal ventral lying	V1	Lying on sternum with legs tucked in and head up or down
Abnormal ventral lying	V2	Ventral lying with hind limbs partially or fully extended or keeping scrotal region off the ground (dog sitting)
Ventral lying other	Vu	Lamb was lying ventrally but unable to clearly categorise the lying posture
Lateral lying	L	Lateral (on side) with one shoulder on ground, extension of hind limbs with head up or down
Abnormal lying	L+ V2	Abnormal lying categories pooled
Total lying	V1+V2+Vu+L	All lying categories pooled
Normal standing	S1	Standing with no apparent abnormalities
Statue standing	SS	Immobile standing with an obvious withdrawal from interaction with other pen members and outside stimuli. Legs positioned further back than normal. Can show arched back.
Abnormal standing	S2	Standing hunched or unsteadily, often associated with foot stamping, kicking and tail wagging
Standing other	Su	Lamb was standing but unable to clearly categorise the standing posture
Normal walking	W1	Walking with no apparent abnormalities
Abnormal walking	W2	Walking unsteadily or stiffly, includes walking backwards, on knees, moving forward with bunny hops, circling, leaning or falling.
Walking other	Wu	Lamb was walking but unable to clearly categorise the walking type
Feeding	Feed	Feeding at the trough
Suckling	Sk	Drinking from the ewe
Total standing	S1+S2+SS+Su+W1 +W2+Wu	All standing and walking categories pooled
Total Abnormal postures	V2+SS+S2+W2+L	All abnormal posture categories pooled

2.4. Analysis of the results

The change in active pain related behaviors over time during the first hour was analyzed in a repeated measures model.

Data for the first hour were suitable for analysis without transformation, with the exception of eating at the trough and the time course of active pain behaviors, which were log transformed. Liveweight was tested as a covariate and fitted when significant ($P < 0.050$). Sham handled lambs were not present in all pens, so pen (i.e. group) was not fitted in the analysis as pen was confounded with treatment. The counts of postures in hours 2 and 3 were combined for analysis, so that 12 counts were recorded per animal for hour 1 and 12 counts for hours 2 and 3 combined. In hours 2 and 3, the number of observations for each lamb varied between 7 and 12. For animals available for observation on fewer than 12 occasions, scores for each posture were rescaled to 12. The change in postures over time was analyzed in a repeated measures model. Plotted data are least squares means ± standard error, except for back transformed values where error bars are not plotted.

3. Results

3.1. Behavioral responses

There was a significant effect of treatment on abnormal lying postures in the first hour ($P < 0.001$). Ring displayed a significantly higher count of abnormal lying than Ring LA or Sham ($P = 0.001$). There was no difference in abnormal lying between Sham and Ring LA lambs ($P = 1.000$) (Figure 2a).

The data for analysis of change in abnormal lying over time could not be normalized by transformation but there was a substantial reduction in abnormal lying in hours 2 and 3 in the Ring and Ring LA groups (Figure 2b).

There was a significant effect of treatment on abnormal walking in the first hour ($P < 0.002$). Ring displayed a significantly higher count of abnormal walking than Ring LA or Sham in the first hour ($P < 0.002$, Figure 2c). There was no difference in abnormal walking between Sham and Ring LA lambs ($P = 0.763$, Figure 2c). No abnormal walking was observed in hours 2 and 3.

There were few instances of abnormal standing in the first hour and the effect of treatment was not significant ($P = 0.293$, Figure 2d).

The was a significant effect of treatment on the combined count of abnormal postures in the first hour ($P < 0.001$, Figure 2e). Ring displayed a significantly higher count of combined abnormal postures than Ring LA or Sham ($P < 0.001$). There was no difference in abnormal postures between Sham and Ring LA lambs ($P = 0.716$).

Data for analysis of change in abnormal standing over time could not be normalized by transformation and there were few instances of abnormal postures in hours 2 and 3.

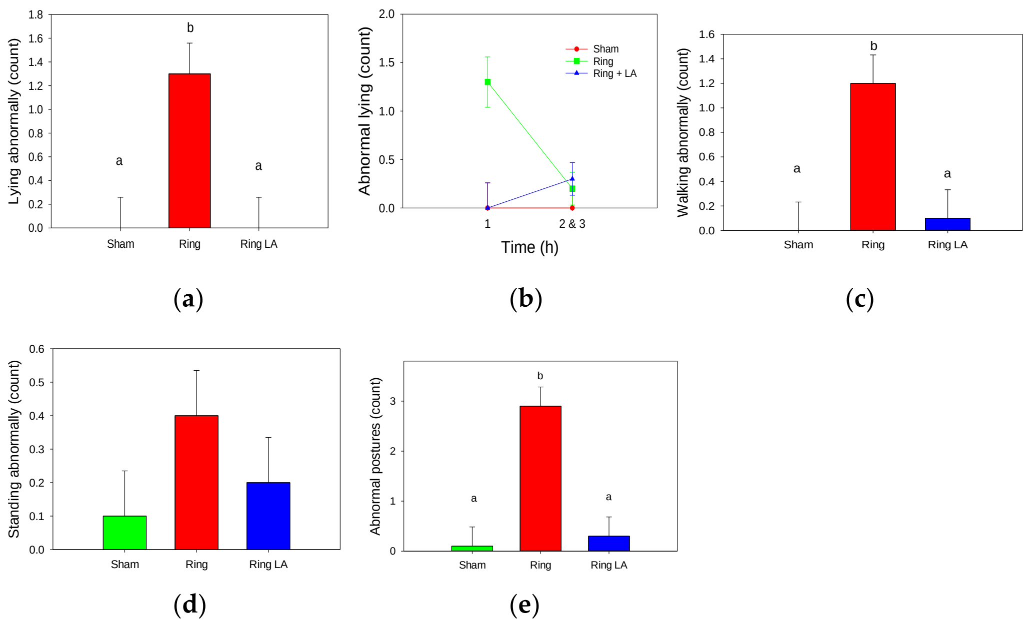

Figure 2. Abnormal postural behaviors in lambs after tail docking with (Ring LA) or without (Ring) anesthetic, or sham treatment (Sham). Individual graphs show lambs (**a**) lying abnormally (counts over entire duration), (**b**) lying abnormally over time, (**c**) walking abnormally (counts over entire duration), (**d**) standing abnormally (counts over entire duration), and lambs demonstrating (**e**) abnormal postures (counts over entire duration). Data points with a matching lowercase letter indicate no significant differences between those data points.

There was a significant effect of treatment ($P < 0.001$), time ($P < 0.001$) and a significant treatment by time interaction ($P < 0.001$) on active pain behaviors in the first hour. (Figure 3a). The count of active pain behaviors was higher in Ring than Ring LA lambs at 5, 15, 25 and 30 minutes ("a" in Figure 3a) and approached significance at 10 and 20 minutes. There was no significant difference in active pain behaviors between sham and Ring LA lambs at any time point. The low frequency of counts of active pain behaviors at any single time point make this analysis less sensitive than the analysis of counts summed over the 60-minute observation period (Figure 3b). The effect of treatment on the combined count of active pain related behaviors in the first hour was significant ($P < 0.001$, Figure 3b). Ring displayed a significantly higher count of active pain related behaviors ($P < 0.001$) than Ring LA or Sham. There was no difference in active pain behaviors between Sham and Ring LA lambs ($P = 0.861$).

There was a significant effect of treatment on teat seeking in the first hour ($P = 0.045$). Applying the ring tended to reduced teat seeking behavior in the first hour in Ring ($P = 0.08$) and decreased teat seeking in Ring LA ($P = 0.016$, Figure 3c), however Ring and Ring LA did not differ ($P = 0.465$). Treatment tended to reduce suckling behavior in the first hour ($P = 0.054$, Figure 3d), but overall Ring LA apparently did not improve a lamb's ability to drink from its ewe in comparison with Ring.

There was no effect of treatment on eating at the trough ($P = 0.191$) in the first hour, but the count for this activity was very low (Figure 3e).

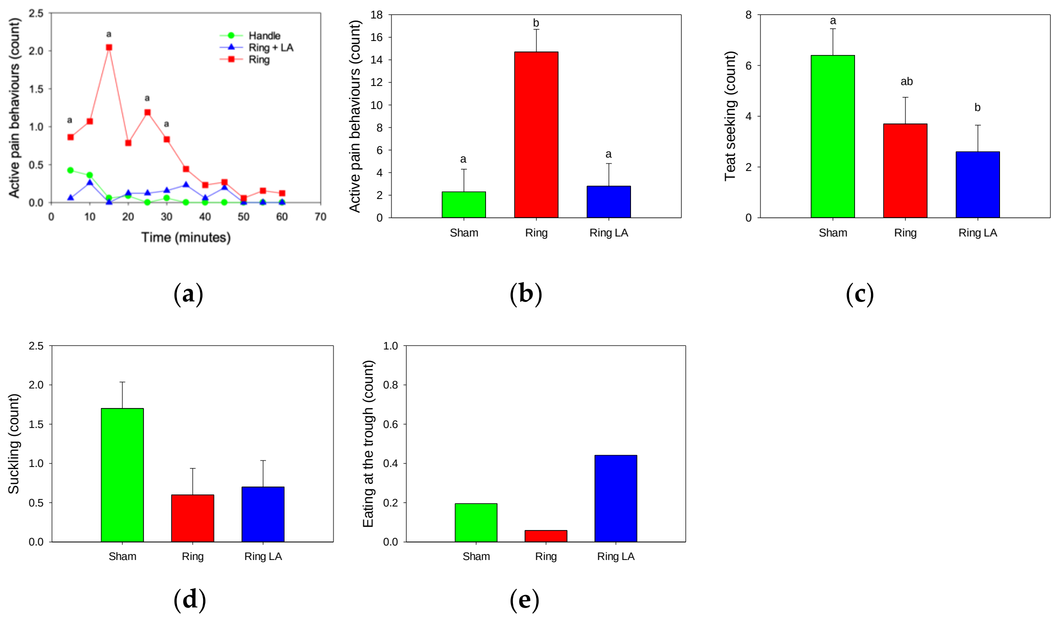

Figure 3. Graphs of active pain avoidance behaviors in lambs after tail docking with (Ring LA) or without (Ring) anesthetic, or sham treatment (Sham) in the first hour. (**a**) total active pain behaviors over time, (**b**) total active pain behaviors (counts over entire duration), (**c**) teat seeking (counts over entire duration), (**d**) suckling (counts over entire duration), and (**e**) eating at the trough (counts over entire duration). Data points with a matching lowercase letter indicate no significant differences between those data points. See text for P values.

Discussion

The current trial showed that injection of 1.5ml local anesthetic into the tail using the prototype device at the time of ring application abolished abnormal behaviors and signs of pain in the first hour after tail docking. However, the lambs in the Ring LA group spent less time attempting to suckle, suggesting that some residual discomfort may have remained. These results corroborate those of a subsequent field trial, where using the Numnuts® device to apply the ring and lignocaine suppressed the degree of pain observed following tail docking [6], and align with several other studies which showed the benefits of local anesthetic delivered by syringe and needle [1, 7, 8].

The provision of pain relief for lambs undergoing painful husbandry procedures has increased over the last few years. Producers now have access to registered, easy to use products such as Tri-

Solfen [9-11] and Buccalgesic [12-14] for surgical procedures such as mulesing, castration and tail-docking. However, prior to development of the Numnuts® device, there was a limitation to feasible acute pain relief provision for ring tail docking [6]. Previous research looked at the use of Tri-Solfen in providing pain relief for lambs undergoing hot knife tail docking (the lambs were concurrently ring castrated without the application of LA), however the topical formulation had minimal impact on behaviors when applied to the open wound on the tail in lambs that were concurrently castrated with a ring [15]. There has also been work that looked at coating rubber rings in lignocaine as a method for delivering pain relief [7]. The lignocaine-coated rings ameliorated some of the pain in response to ring castration when compared to normal rings, however they were not as effective as injection of lignocaine [7]. Absorption of lignocaine through intact skin is limited and delivery of pain relief via this route is slow and does not adequately address the acute pain phase of ring castration and tail docking. In the present study, application of a metered dose of lignocaine using the prototype Numnuts® device significantly reduced the acute pain response in lambs that underwent ring tail docking.

The present study demonstrated that the Numnuts® device can provide immediate pain relief for the acute pain phase of ring tail docking in lambs. Subsequent large-scale on-farm trials have shown that, after a little practice, the Numnuts® device does not slow the process of lamb marking with rings [Robin Smith, Senesino Ltd, personal communication]. That observation, combined with the present results, indicate that sheep producers now have a rapid, practical and safe method for large scale relief of pain caused by tail docking.

Author Contributions:

- Alison Small – conceived and designed the study, interpreted data;
- Ian Colditz – performed data analysis, interpreted data;
- Danila Marini – prepared manuscript discussion and interpreted data in the context of existing literature.

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