Title: Development of a practical, cost-effective pain mitigation technique for castration of piglets – NPB #12-107 revised

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Industry Summary:

There is a growing trend towards the development of “welfare-friendly” management practices in production animals. Castration of piglets has gained considerable attention and there is growing pressure on the pork industry to develop management practices that address the pain associated with castration. The main objective of this experiment was to develop an effective, cost-effective and practical method of mitigating pain associated with castration in piglets. Two local anesthetic administration systems that would be easy to adopt in a commercial setting were examined; a needle free injection system (Acushot S) and a multidose injection syringe with a needle (Merial Pullet syringe). The project was divided into three separate experiments to examine the efficacy of the techniques and practical effects when implemented into a production system. Efficacy was measured using physiologic and behavioral measures of pain during administration of the local anesthetic and during castration. Behavioral measures of pain included using pain scores and vocalizations during anesthetic administration and castrations. Vocalizations have been shown to provide a valid measure of pain during castration in piglets. Piglets undergoing castration without anesthetic have higher frequency calls for longer periods of time than piglets that are handled but not castrated. Effect on processing times, cost implications, and perceptions of technical staff performing the processing procedures were evaluated.

In part 1 of the study, 30 3-4 day old male piglets were randomly assigned to receive a local anesthetic (lidocaine) injection into the testicles using a needle-free injector (ACUSHOT), a multidose injection syringe (NEEDLE), or no injection of lidocaine (SHAM). The time to achieve desensitization of the testicles was measured. Pain associated with castration was evaluated by measuring blood cortisol and lactate levels, eye and scrotal temperatures, and skin sensitivity over the castration site (pressure algometer). In part 2 of the study, 116, 2-3 day old male piglets were randomly assigned to receive one of the following; 1) local

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anesthetic and castration 2 minutes later (LIDO 2), 2) local anesthetic and castration 4 minutes later (LIDO 4), or 3) no anesthetic and castration after 2 minutes (CONT). In the local anesthetic groups, lidocaine was injected using a multidose needle injection syringe. Pain during anesthetic administration and during castration was measured using behavioral scoring (VAS) and vocalizations. Part 3 of the study examined implementation of the multidose needle injection syringe into routine piglet processing on the farm. Twenty-four litters of piglets were assigned by row to receive either local anesthesia or standard processing without anesthetic. The anesthetic was administered to all male piglets as they were removed from their pen and placed into a cart. Processing then occurred as follows: tail docking, antibiotic/iron injection, ear tattooing, and castration. Two to three processors, who routinely performed the processing on farm, worked together on each litter. The time to process each litter, time to process each row, males per litter, litter size, and minimum time from anesthetic administration to castration were measured. At the end of the study, individuals involved in the processing procedure completed a short questionnaire.

The major results found in the study included:

- The needle–free injection system (ACUSHOT) did not reliably produce anesthesia sufficient for castration. It was therefore removed from part 2 and 3 of the study.
- Injection of lidocaine with a needle (NEEDLE) was 92% effective within 2 minutes of administration.
- There was no significant difference in blood lactate, cortisol, pressure algometer readings, or eye and scrotal temperatures between any of the groups in part 1 of the study.
- Lidocaine administration significantly reduced pain during castration. Piglets receiving a local anesthetic struggled less and squealed at lower frequencies than piglets that did not receive an anesthetic. There was a beneficial effect of lidocaine both 2 and 4 minutes after administration.
- Lidocaine administration is less painful than castration without an anesthetic. The procedure of administering lidocaine resulted in piglets vocalizing less and at lower frequencies than the castration procedure itself.
- There was no significant difference in litter processing times when lidocaine administration was incorporated into the processing procedure. Although mean lidocaine administration time was 98 seconds, compared to 30 seconds in the control group, it took on average only 3 seconds longer to process each litter individually, or 34 seconds longer if continuously processing multiple pens in a row.
- Cost of treatment is relatively small. Implementation of lidocaine into routine processing would cost less than $1USD/litter. Currently there are no pain mitigation products in the US or Canada labeled for use in swine. Therefore, any pain medication used must be done under the direct supervision of a licensed veterinarian. In Canada veterinary approved products are available under prescription by a licensed veterinarian.
- Of the processors surveyed, all felt that the injection technique was easy and safe to perform, and if implemented on their farm, they could make it work within their system.

The results of this study support the implementation of local anesthetic administration into routine piglet processing. This study shows that local anesthesia reduces pain during castration with no impact on processing times, no major changes in the processing procedure, and with minimal additional cost. With increasing attention geared toward animal welfare and new regulations being implemented in other countries in regards to castration, this study provides a cheap, effective and practical method of mitigating pain during castration in piglets.

It is important to note however, that local anesthesia is effective at reducing pain during castration; it does not provide post-operative pain relief after castration has been performed (supported by our findings of no differences in cortisol, lactate, eye temperatures, and algometer readings in the 6 hours after castration). Therefore, this technique should be incorporated with the administration of an analgesic, such as meloxicam, in order to address the pain both during and after castration.

When considering implementation into a production setting, drug availability and appropriate drug use must also be considered. Currently there is no FDA labeled lidocaine product available for use in swine in the US. This means that an FDA human labeled product must be used extra-label under the supervision of a licensed veterinarian. In Canada, there are veterinary approved lidocaine products for use in swine however, they may also only be used under direction of a licensed veterinarian.

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Keywords: castration, piglets, pain, lidocaine, production, local anesthesia

Scientific Abstract:

Introduction: The main objective of this experiment was to develop an effective, cost-effective and practical method of mitigating pain associated with castration in piglets. **Materials and Methods:** The study was performed in 3 parts. Part 1 examined the efficacy and onset time of lidocaine using two different administration systems. Thirty 3-4 days old male piglets were randomly assigned to receive one of the following: 1) lidocaine 1%(14 mg) administered by needle free injection (ACUSHOT); 2) lidocaine 1% (15 mg) administered by a needled multi-injection syringe (NEEDLE); or 3) untreated control group (SHAM). Pain during and after castration was measured using behavior, vocalizations, serum cortisol and lactate, force algometry and infra-red thermography over six hours. Part 2 examined the effect of lidocaine administered by a needled, multi-injection syringe on vocalizations and pain scores (VAS) during anesthetic administration and castration. 120, 2-3 days old male piglets were randomly assigned to receive one of the following: 1) handling but no anesthetic administration and castration after 2 minutes(CONT); 2) lidocaine 1% (15 mg) and castration after 2 minutes (LIDO 2); or 3) lidcoaine 1% (15 mg) and castration after 4 minutes (LIDO 4). Lidocaine was administered using a multi-injection needled syringe. Part 3 implemented the injection technique into a production setting compared to standard processing procedures to assess the cost and time implications on production. Twenty-four litters were randomly assigned to either a lidocaine or untreated control group. Times to process each litter, each row, and to administer the lidocaine were measured. Individuals performing the processing on the farm were given a questionnaire.
Results: Part 1: ACUSHOT was found to not reliably inject the anesthetic. NEEDLE was 92% effective after 2 minutes. There were no significant differences between any group or over time in serum cortisol, blood lactate, or pressure algometry. SHAM piglets tended to have a higher maximum frequency and high frequency (>1000Hz) call rate than NEEDLE, however these results were not statistically significant. Part 2: Lidocaine (LIDO2 and LIDO 4) significantly decreased VAS and increased low frequency call rates. Maximum frequency and high frequency call rates were also lower in LIDO 4 compared to CONT. There was no significant effect on time to process each litter or corrected row processing times when local anesthetic was incorporated into routine piglet processing on the farm, in a 2 cart system with 2-3 processors. Material costs were less than $1 USD per litter. Processors felt that the technique was easy and safe to perform and that they could make the technique work if it were adopted within their system.
Conclusions: The results of this study suggest that local anesthesia using lidocaine and a multidose, needle syringe is effective, easy to perform, economic and practical for use in a production setting.

Introduction:

Animal welfare is becoming increasingly important in food animal production. In some European countries, regulations are being implemented banning castration in pigs. In order to remain competitive in the international market, practical pain management strategies need to be developed to address these welfare issues. In the US, public perceptions and consumer demands regarding animal welfare will have impacts on the industry. Creating pain management techniques that address welfare concerns as well as being feasible for use in a commercial setting, would allow the US pork industry a tool to address potential future public and export demands.

It is well established that castration of piglets is painful and that local anesthetics, such as lidocaine, reduce pain (Kluivers-Poodt M. et al 2012, Hansson M. et al 2011). Currently proposed methods of local anesthetic administration are not practical in a commercial setting as they require piglets to be handled twice and significantly increase labor costs. There is a need to develop pain management strategies for castration in piglets that are not only effective, but also can be feasibly implemented by industry. This research examined the use of a multidose needle injection syringe and a needle-free injection system, both of which are currently commercially available, for administering lidocaine immediately before castration. These injection methods allow for multiple rapid injections without the need for drawing up anesthetic between injections. Both systems reduce anesthetic administration times when multiple animals are being treated and can be used with one hand. Immediate processing after anesthetic administration minimizes additional labor costs and the need to handle the piglets twice. Both methods have the potential for practical application within a commercial setting, with minimal economic and management impacts on producers.

This research addresses some of the industry's concerns regarding the practicality and economics of using pain management for castration in piglets. It will not only look at pain management but will also address effects on production, time to perform the procedure and ease of use in a commercial setting. The end goal of this project is to provide the US pork industry with a pain management technique for castration of piglets that can be feasibly implemented in production.

Objectives:

This study examined the use of 2 different local anesthetic administration methods for use during castration in piglets. The main objectives of the study were to:

- Examine whether lidocaine injection into the testicles has an immediate effect in reducing pain during castration and can be effectively used in a routine piglet processing setting
- Evaluate the efficacy of 2 anesthetic administration systems that are safe, practical and easy to perform by producers
- Provide industry with a pain management technique that is both effective, economic and feasible for use within current production practices

Materials & Methods:

The objectives of this project were examined in three parts to address physiological, behavioral and practical effects of anesthetic administration before castration in piglets. The research was conducted at Verus Swine Health Management Services, Sow Site #1. All animals used in the study were part of a commercial operation and were housed in standard farrowing pens with their sow. There were 36 farrowing pens per room (4 rows of 9 pens). Before each experiment, male piglets were weighed, and identified with a litter and individual number on their back. For parts 1 and 2, all males used in each litter were collected and transported to a mechanical room down the hall from the farrowing room to keep background noise to a minimum. Piglets were kept in the mechanical room during anesthetic administration and castration. Once castration was completed on all males within a litter, they were returned to their pen and the next litter was started. Routine processing (tail docking, tattooing, and injections) was performed at least 24 hours after the end of the experiment. For part 3 of the study, piglets were processed outside of their pens, as is done routinely on the farm.

Pilot study

10 male piglet cadavers and lidocaine 2% with epinephrine containing new methylene blue were used to develop the injection technique for the Acushot S. A pink cartridge and 0.5 ml per injection gave the most reliable injection technique. The needle free injection method was unable to penetrate the testicle however, using the technique described below, it did surround the spermatic cord in local anesthetic. The ideal method was found to be by holding the piglet's hind limbs in one hand and pressing the testicles together with the limbs. The tip of the injection gun was placed firmly at the base of the scrotum, just ventral to the testicle, and angling the nozzle at 90 degrees to the skin. This technique gave the most consistent injection of lidocaine that migrated proximally along the spermatic cord towards the external inguinal ring.

Additionally, on the first day of part 1 of the study, 2 live piglets were used to ensure the technique was effective.

Part 1- Physiological and behavioral measures of pain

Thirty, 3-4 day old male piglets weighing an average of 2.29 kg (1.81-2.89kg) were matched by litter and randomly assigned to one of three treatments: 1) local anesthesia using a needle free injection system (ACUSHOT); 2) local anesthesia using a multi-injection gun and a 25 gauge 5/8 inch needle (NEEDLE); 3) handling but no injection of local anesthesia (SHAM). After the first 7 litters were treated (21 piglets), it was found that the Acushot was not reliably injecting through the scrotal skin, despite it having worked in the pilot studies. Therefore, the remainder of the piglets were randomly assigned to the remaining two groups (matched by litter) and this treatment was removed from the remainder of the trial.

Anesthetic technique

Local anesthesia comprised of 0.5ml lidocaine 1% (with epinephrine) into each testicle and 0.5 ml infiltrated under the skin of the scrotum (total 1.5 mL (15 mg) lidocaine). To achieve a 1% concentration of lidocaine, lidocaine 2% with epinephrine was diluted with an equal volume of 0.9% sterile saline. In the Acushot group, an Acushot S with a pink cartridge was used. The nozzle of the injector was held perpendicular to the skin over the scrotum just ventral to the testicle. Onset of anesthesia of the scrotal skin was measured by needle prick using a 25 gauge 5/8 inch needle into each testicle every 30 seconds for up to 2 minutes (maximum 4 skin pricks) or until the piglet stopped responding. Piglet responses were evaluated by the amount of struggling and vocalization associated with each pin prick compared to restraint alone. From the time of anesthetic administration to the onset of anesthesia (or first 2 minutes) piglets remained hand restrained, to minimize struggling attempts and vocalization from repeated capturing. If the piglet still responded to needle prick after 2 minutes, the block was considered to have failed. The number of failed blocks were recorded. In part 1, piglets were restrained by holding the piglet upside down with both hind legs held in one hand.

Castration technique

All piglets were surgically castrated as per industry standard using a scalpel blade. Piglets were restrained by holding both hind limbs in one hand with the piglet's head hanging towards the ground. A scrotal incision was made over each testicle but not through the tunica vaginalis. Both testicles were exteriorized and then removed by pulling the testicles until the spermatic cords tore. Any loose tissue exiting the incisions was removed and the incisions were left open to heal by second intention healing.

Measures of pain

I. Behavior

   Pain during anesthetic administration and castration was assessed using vocalization frequencies and a Visual Analogue Score (VAS) (Figure 1). VAS was measured by a single observer who was blinded to treatment administered and measured the degree of struggling during each procedure. Vocalization frequencies during anesthetic administration and castration were captured using a video camera (Sony handycam) placed an equal distance away from each piglet's snout. Audio data was analyzed using Raven Software and the duration (in seconds), mean frequency (Hz), and frequency of peak amplitude (Hz) of the vocalizations were quantified (Marchant-Forde et al., 2009).

A video camera was mounted from the roof over each farrowing pen to record piglet behavior for 6 hours after castration.

II. Force algometry

A hand held force algometer (Pro D Plus, TopCat Metrology) was applied over the scrotum and pressure exerted until a positive response (struggling or squeals) was observed. Measures were obtained at the following time points: baseline, castration, and 0.5, 1, 2, 4, 6 hours after castration.

III. Infrared thermography

Infrared images of the eye and scrotum were obtained using a hand held thermography camera (FLIR) at baseline, castration, 0.5, 1, 2, 4 and 6 hours after castration. Infra-red images and force algometry readings were collected before the piglet was restrained for blood collection.

IV. Serum lactate and cortisol

Piglets were restrained either by holding the piglet upside down with its back against the abdomen of the individual restraining the piglet, or by placing the piglet on the restrainer's lap (as a v-trough). Roughly 1.5-2 mL of blood was collected from the anterior vena cava using a 20 gauge 1 inch needle and vacutainer. Lactate was measured immediately after blood collection with a handheld lactate meter. The remainder of the blood was put on ice and kept refrigerated until it could be spun down at the end of the day. Serum was collected and stored at -80C until cortisol testing was performed. Cortisol was measured using a commercial cortisol assay kit (Cortisol EIA kit, Assay Designs) by an independent laboratory. All samples were measured in duplicate.

Part 2- Behavioral measures of pain

116, 2-3 day old male piglets weighing 1.6 kg (range 0.81-2.71 kg) were matched by litter and randomly assigned to receive one of three treatments: 1) CONT (n=39) piglets were handled but did not receive any anesthetic treatment and castrated 2 minutes after handling; 2) LIDO 2 (n=38) piglets received lidocaine anesthesia and were castrated 2 minutes after injection; and 3) LIDO 4 (n=39) piglets received lidocaine anesthesia and were castrated 4 minutes after injection. Lidocaine anesthesia was performed by injecting 0.5 ml lidocaine 1% with epinephrine into each testicle and another 0.5 ml under the scrotal skin (total 1.5 ml) using a mulitdose injection gun (Merial pullet syringe 0.5ml) and a 25 gauge ¾ inch needle. Lidocaine 2% with epinephrine was diluted with an equal volume of sterile 0.9% saline prior to injection. For anesthetic administration, piglets were held upside down by grasping them around the caudal abdomen and using a thumb to keep the testicles immobilized during injection. Castration was performed as described in Part 1. Pain during anesthetic administration and castration were assessed using a Visual Analogue Score (VAS) (Figure 1) and vocalizations. A single blinded observer performed all VAS measurements. Piglet vocalizations were recorded during anesthetic administration and during castration using a handheld audio recorder (Sony Linear PCM–D50 Recorder) held at a standard distance from the piglet's snout. Vocalizations were analyzed using Raven Pro 64 1.4. Using waveforms, spectrograms and selected spectrums, peak frequency or frequency of maximum power (Hz), maximum power (dB), maximum frequency (Hz), number of high (>1000 HZ) and low (<1000 HZ) frequency calls, total calls and rates of high and low calls (calls/sec) were analyzed. After all piglets in a litter were treated, they were given 0.4 mg/kg meloxicam under the skin and returned to their pens.

Part 3- Use of technique in a production setting

The feasibility of using the local anesthetic technique in a routine processing setting was evaluated over 2 days of processing on the farm. The staff performing the piglet processing were trained to the use of the injection gun and appropriate injection technique through a demonstration and then by practicing the technique on 1 litter of piglets. The litters of piglets to be processed each day were randomly assigned by row to receive either local anesthesia with the multidose needle syringe (LIDO; n=13 litters) or no treatment (CONT; n=12 litters) so that the anesthetic technique could be implemented in a continuous fashion over the entire row. On the farm, piglet processing normally occurs by working between 2 rows of farrowing pens. There are 4 rows of pens per room. For ease of implementation, each room was divided into 2 so that all piglets in an adjacent 2 rows received the same treatment.

The normal processing procedure on this farm was as follows:

Piglets were removed from 1 pen and placed into a cart. They were then removed individually, tail docked, and returned to the cart. After tail docking, piglets were injected in the neck muscle with an antibiotic and iron supplement and placed into a second cart. Piglets were then removed from the second cart, ear tattooed, and castrated before being returned to their pen. Teeth clipping and an oral anti-diarrheal medication was administered as needed in some piglets. Processing occurred using either 2 or 3 processors working together so that one individual collected pigs from each litter and performed the tail docking while the other 1-2 processors, performed the injections, tattooing and castrations.

For the anesthetic treatment group, male piglets were injected with 0.5 ml lidocaine 1% with epinephrine into each testicle and another 0.5 ml under the skin as described above. Lidocaine injection was performed as each male piglet was removed from the pen, before being placed into the first cart. There was no specific order in regards to pulling the males and females from the pen, nor in the order of processing of males and females. Processing then occurred as described above. The needle was changed between each litter.

The following variables were recorded:

- Treatment time= Time to perform lidocaine injection (LIDO) or place piglets into the first cart (CONT). This was recorded as the time from the first piglet being picked up from the pen to the last piglet being placed in the first cart.
- Minimum anesthetic onset time= Time between lidocaine administration of the last piglet and castration of the first piglet in the litter (the time from the last piglet being placed into cart 1 to the first piglet being tattooed)
- Time to process Litter- calculated as the time the first piglet was removed from the pen to last piglet being returned to the pen
- Row processing time- time from first piglet pulled from the pen in a row to the last piglet returned to its pen in the row
- Corrected row processing time= the row processing time divided by the number of litters processed in the row.
- Number of males per litter
- Litter size

After the second day of processing, a short questionnaire was given to the farm staff involved in the processing (Figure 2) and comments regarding the anesthetic procedure were collected.

Data Analysis

Serum cortisol, blood lactate, and force algometer data were analyzed using two-way ANOVA, with a Bonferroni post-test. Vocalization and VAS data were analyzed with a 1-way ANOVA. Timed data from the production study were analyzed using a two-tailed T-test. Differences were considered statistically significant in $p<0.05$.

Results:

Objective 1: Examine whether lidocaine injection into the testicles has an immediate effect in reducing pain during castration and can be effectively used in a routine piglet processing setting (Part 1)

- ACUSHOT was 58% (8/14 testicles) effective after 2 minutes. Median onset time was 30 seconds. NEEDLE was 92% (22/24) effective with a median anesthetic onset time of 30 seconds. All of the piglets in SHAM responded to needle prick over both testicles for 2 minutes.
- There was no significant difference between treatments groups in lactate, cortisol, or force algometry measures at any time($p>0.05$) (Figure 3). Serum cortisol levels in both groups increased at 30 minutes and 1 hour after castration, but the change was not statistically significant ($P>0.05$). Force algometer measures decreased significantly compared to baseline at 0.5 hr, 2 hr, 4 hr, and 6 hr after castration in the NEEDLE group and at 4 hr and 6 hr after castration in the SHAM group ($P<0.05$). This means that less pressure was required to achieve a response, indicating increased sensitivity over the scrotum after castration in both treatment groups.
- Eye and scrotal temperatures did not differ significantly between treatment groups ($P>0.05$) (Figure 4). Scrotal temperatures decreased over the first six hours after castration in both groups.
- The rate of high frequency calls(>1000 Hz) was higher in SHAM (8.92 ± 1.6 calls) and ACUSHOT (8.92 ± 1.4 calls), than NEEDLE (7.35 ± 1.5 calls), however these results were not statistically significant ($p>0.05$). There was no significant difference in maximum frequency distribution, call duration, or VAS between the groups in part 1 of the study.

Objective 2: Evaluate the efficacy of 2 anesthetic administration systems that are safe, practical and easy to perform by producers (Part 2)

- Anesthetic administration reduces pain associated with castration. CONT piglets had a significantly higher mean VAS score and number of high frequency calls, fewer low frequency calls, and a lower low call rate than LIDO 2 or LIDO 4 piglets ($p<0.01$). Maximum frequency ($p=0.03$) and high call rates ($p=0.01$) were also significantly higher in CONT compared to LIDO 4 (Table 2)
- Anesthetic administration is not significantly painful. Anesthetic administration resulted in significantly higher maximum frequency ($p=0.01$) and maximum power ($p=0.01$) than control piglets that were handled alone. However, there was no difference in high and low call rates or VAS score between any of the groups ($p=0.17$) (Table 1).
- Anesthetic administration is less painful than castration without anesthesia. Animals castrated without anesthetic (CONT) had a higher maximum frequency than either of the LIDO 2 or LIDO 4 administration groups ($p<0.01$) (Figure 5)

Objective 3: Provide industry with a pain management technique that is effective, economic and feasible for use within current production practices (Part 3)

- Litter size and males per litter did not differ significantly between the two groups. The average litter size was 12.3 (range 12-13) and 12.5 (range 10-14) for CONT and LIDO, respectively. There were an average of 5.2 (range 1-9) males in each CONT litter and 4.9 (range 1-7) males in each LIDO litter.
- Incorporating the anesthetic administration technique into the routine processing procedure did not significantly affect litter processing times when 2-3 processors were involved in the processing (Table 3). Although the treatment time was significantly longer in the LIDO group than CONT ($p<0.01$), there was no significant difference between the groups in the time to process each litter ($p=0.91$) or corrected row processing time ($p=0.38$).
- There was sufficient time, without changing the routine processing procedure, for the local anesthetic to take effect. On average, there was 2 min 49 seconds between the last piglet receiving local anesthesia and the first piglet to be processed in the LIDO group (Table 3). Therefore, most piglets in a litter would have over 3 minutes for the lidocaine to take effect.
- Cost of implementing local anesthesia is low. As there was no effect on processing times, the only increase in cost in implementing lidocaine anesthesia is the cost of materials. In our study, it cost less than $1 USD to process each litter.

- All processors surveyed (n=3) either agreed or strongly agreed that the lidocaine injection was easy to perform. None were concerned about potentially injuring themselves during injection. All processors agreed or strongly agreed that implementing the lidocaine injection would increase processing times. This was particularly a concern if processing with only 1 processor. That said, all processors agreed that they would be able to make the technique work in their production system and they were all neutral as to whether castration was easier to perform.

Discussion:

The results of this study suggest that local anesthesia using lidocaine and a multidose, needle syringe is effective, easy to perform, economic and practical for use in a production setting. Despite the perception that anesthetic administration will increase processing times, when 2-3 processors were involved in processing using a 2 cart system, there was no difference in the time to process each litter. Litter processing times reflect processing one litter at a time. The corrected row processing time took into account that in a two cart system with 2-3 processors, two litters may be undergoing some stage of the processing procedure at the same time. On the farm in the current study, approximately 15-20 litters may be processed each day. Based on this assumption, daily processing would increase by a maximum of 9 to 12 minutes if local anesthesia were implemented. This is especially important as the technique was new to the staff on the farm during the data collection period. If adopted into the production system and allowing staff time to perfect the use of the technique, anesthetic administration times would become shorter. In smaller production systems where only one person performs the processing, processing times would be longer by a minute per litter.

Previous studies have shown the beneficial effect of local anesthesia on pain during castration (Hansson M, et all 2011, Kluivers-Poodt M, et all 2012, Haga HA and RanheimB 2005). Most of these studies waited 10-15 minutes after anesthetic administration, before castration. In a production setting, this would not be practical. There is some evidence suggesting that onset times for local anesthetics are much more rapid (Collins JB et al 2013, Fierheller EE et al 2012,Ranheim B et al 1005). This study shows that if administered at the beginning of processing (when piglets are removed from their pen) and castration is performed as the last procedure, there is enough time between anesthetic administration and castration for the anesthetic to be effective without changing the processing process.

This study showed a reduction in pain during castration with the local anesthetic. There was no significant difference between the lidocaine groups or untreated control animals in pain reduction post-operatively (Part 1) as cortisol, lactate, eye temperature, and pressure algometry values did not differ significantly between treatment groups. The duration of anesthesia of lidocaine is normally 1-2 hours. Because 2/3 of the lidocaine in this study was injected into the testicles, and the testicles were removed within 2-4 minutes after injection, it is unlikely that the local anesthetic had a long lasting effect on pain after the procedure. For this reason, local anesthesia is the best choice for mitigating pain associated with the castration procedure itself. If implementing pain management into a production system, the local anesthetic should be combined with an anti-inflammatory drug, such as meloxicam, to address the post-operative pain.

Both the VAS and vocalization measures were significantly different in Part 2 between the lidocaine and control groups. VAS is a subjective measure of pain and has been use to evaluate pain in small animals, horses and cattle (Moya et al 2014, Joyce and Hendrickson 2006). To minimize variation in this study, one blinded observer evaluated all of the animals. This observer was trained to the use of the VAS and to normal piglet behaviors during handling and castration. Previous research has shown that piglets castrated without anesthesia have a greater number and a greater frequency of high frequency calls (>1000 Hz) than piglets receiving pain medication (Hansson M et al 2011, Kluivers-Poodt M et all 2012, Haga HA and Ranheim B 2005). In this study, LIDO 4 piglets had a lower maximum frequency and a lower high call rate than control piglets. It is likely that the anesthesia produced after 4 minutes was better than after 2 minutes. That said, LIDO 2 piglets did had significantly lower VAS and higher low call rates than control piglets, suggesting some anesthetic effect after two minutes.

Cortisol and lactate did not prove to be valuable measures of pain during castration in this study. Despite being the “gold standard” test for assessing pain and stress in animals, the value of cortisol as an indicator to differentiate the effect of analgesia on pain varies widely (Haga HA and Ranheim B 2005, Hansson M et al 2011, Kluivers-Poodt M et all 2012). This is likely due to the amount of stress from restraining the animal, causing cortisol levels to be high from handling alone. There is also considerable variability in levels between individuals, making it difficult to show a statistically significant difference, especially with smaller sample sizes. Had a larger sample size been used in part 1 of the study, significant differences may have been easier to detect. In this study, behavior and vocalizations proved to be more valuable than the physiologic measures of pain.

With increasing pressure on the pork industry to develop welfare-friendly management practices, there is a need for pain management options that are effective, but that also can be feasibly adopted into current production systems. This study provides support that local anesthesia of the testicles using lidocaine is effective, safe, easy to perform, and can easily be adopted into current processing practices without significantly impacting cost, time, or staffing requirements. Further changes in drug availability and changes to regulations need to be made to make the use of pain medications for castration in piglets easier to adopt into practice. By proactively implementing pain management systems on farms, the pork industry can effectively address consumer demands.

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Figure 1: Visual Analogue Scale. The 10cm horizontal line represents a pain scale where the left side of the line is no pain and the right side is extreme pain. A vertical line is drawn onto the scale based on behavioral and vocal signs of pain during the procedure.

Animal ID#: Litter #:

No pain ____ Severe Pain

Figure 2: Questionnaire given to individual processors at the farm involved in the trial (n=3)

Use of Local Anesthetic (Lidocaine) Before Castration in Piglets at Processing

Date: November 13, 2013

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Lidocaine injection was easy to perform	**1**	**2**	**3**	**4**	**5**
2. I was concerned I would injure myself when giving the injections	**1**	**2**	**3**	**4**	**5**
3. Lidocaine injection will increase our processing time	**1**	**2**	**3**	**4**	**5**
4. Castration was easier to perform in piglets receiving the lidocaine injection	**1**	**2**	**3**	**4**	**5**
5. If this technique were part of the protocol, I could make it work in our system	**1**	**2**	**3**	**4**	**5**

Figure 3: Comparison of serum cortisol, lactate and pressure algometry in piglets treated with lidocaine and without during and after castration.

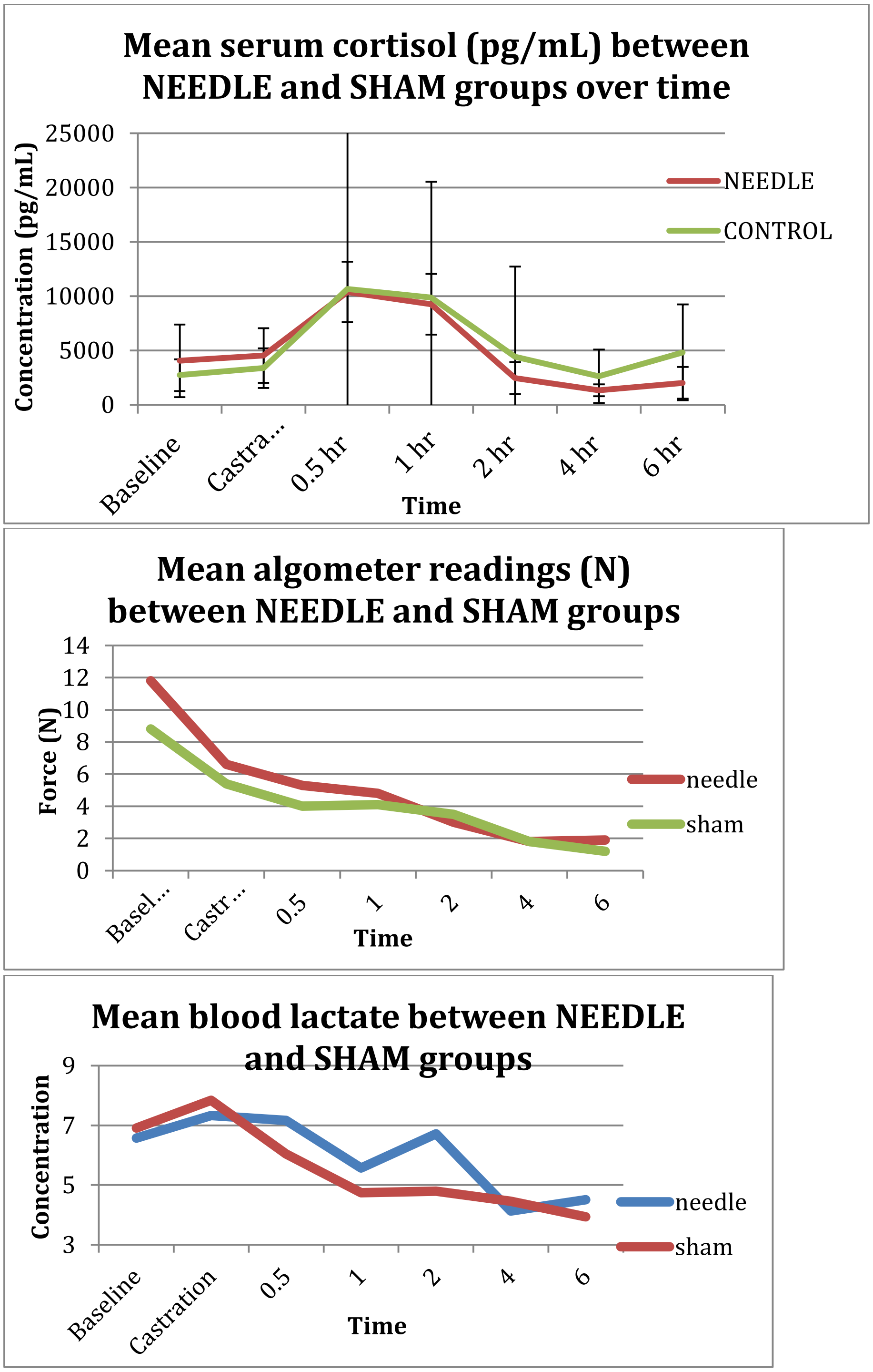

Figure 4: Comparison of eye and scrotal temperatures in piglets treated with lidocaine and without during and after castration

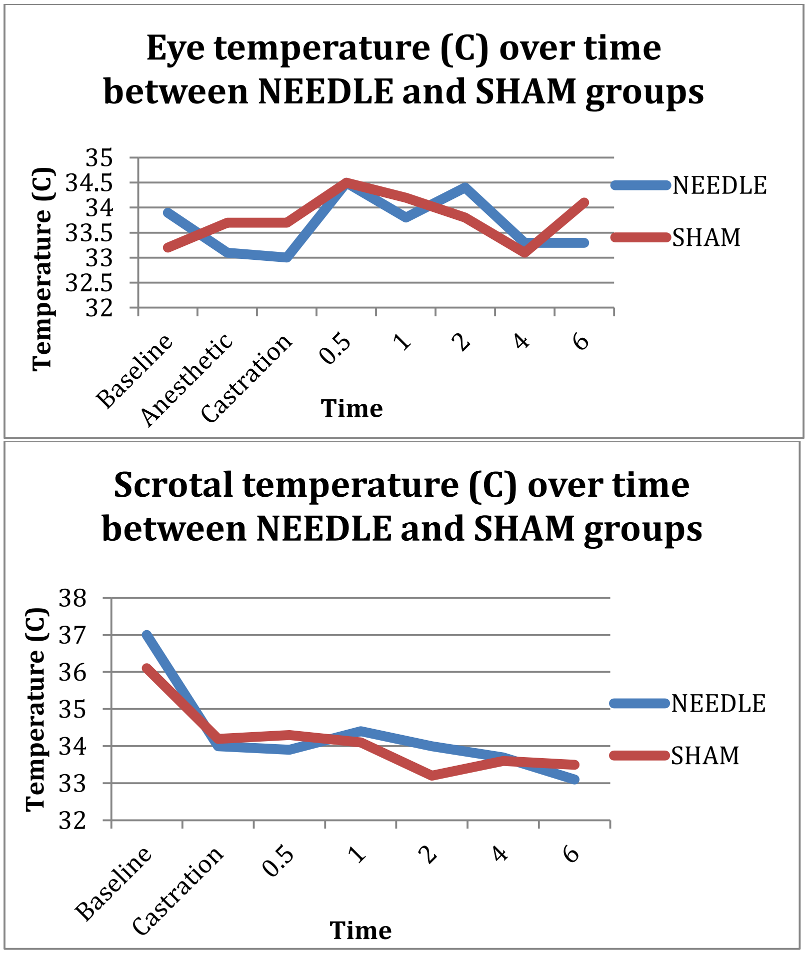

Figure 5: Comparison of pain associated with castration without anesthetic and administration of a local anesthetic.

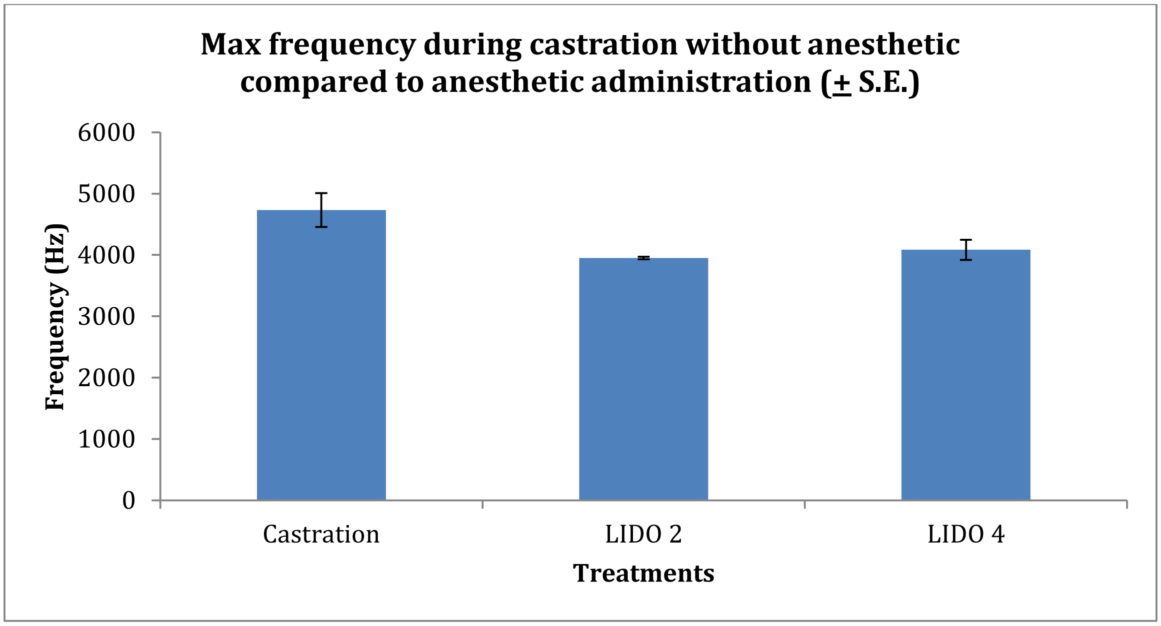

Table 1: Effect of local anesthetic administration on vocalization and pain scores (VAS) during *anesthetic administration* in piglets

Piglet Vocalization and behavior during Anesthetic Administration (means + S.E.)

Treatment	**Max Power (dB)**	**Max Frequency (Hz)**	**High Call Rate (calls/sec)**	**Low Call Rate (calls/s)**	**High Calls (>1000Hz)**	**Low Calls (<1000Hz)**	**VAS**
Control	82.9 ± 3.5 (n=39)	3194.3 ± 265.6 (n=39)	0.6 ± 0.1 (n=39)	0.1 ± 0.1 (n=39)	6.1±0.6 (n=39)	1.2±0.5 (n=39)	5.8+0.3 (n=39)
LIDO 2	91 ± 1.3 (n=39)	3948.9 ± 20.6 (n=39)	0.8 ± 0.0 (n=39)	0.1 ± 0.0 (n=39)	6.4±0.4 (n=39)	1.1±0.5 (n=39)	6.5+0.4 (n=38)
LIDO 4	91.9 ± 0.9 (n=37)	4083.2 ± 163.6 (n=37)	0.8 ± 0.0 (n=37)	0.0± 0.0 (n=37)	7±0.5 (n=37)	0.4±0.2 (n=37)	6.9+0.3 (n=39)

Letters in superscript represent values with statistically significant differences ($p<0.05$).

Table 2: Effect of local anesthetic administration on vocalization and pain scores (VAS) *during castration* in piglets

Piglet Vocalization and Behavior during Castration (means + S.E.)

Treatment	Max Power (dB)	Max Frequency (Hz)	High Call Rate (calls/sec)	Low Call Rate (calls/s)	High Calls (>1000Hz)	Low Calls (<1000Hz)	VAS
Control	91.1 ± 1.1 (n=38)^{a}	4732.8 ± 276.4 (n=38)^{a}	0.9 ± 0.1 (n=39)^{a}	0.2 ± 0.0 (n=39)^{a}	18.3±1.5 (n=39)^{a}	4.3±0.9 (n=39)^{a}	6.4+0.3 (n=39)^{a}
LIDO 2	87.6 ± 1.4 (n=34)^{a}	4261.0 ± 315.1 (n=34)^{a,b}	0.7 ± 0.1 (n=35)^{a,b}	0.5 ± 0.1 (n=35)^{b}	11.8±0.9 (n=35)^{b}	8.7±0.4 (n=35)^{b}	4.6+0.4 (n=38)^{b}
LIDO 4	87.5 ± 1.4 (n=32)^{a}	3580.6 ± 318.3 (n=34)^{b}	0.6 ± 0.1 (n=34)^{b}	0.5 ± 0.1 (n=34)^{b}	10.4±1.4 (n=34)^{b}	9.3+1.2 (n=34)^{b}	4.2+0.4 (n=39)^{b}

Letters in superscript represent values with statistically significant differences ($p<0.05$).

Table 3: Effect of implementing local anesthetic protocol on processing times in a farm setting (mean (range)).

Treatment	Treatment Time, min:sec (range)	Litter Processing Time, min:sec (range)	Min Anesthetic Onset Time, min:sec (range)	Corrected Row Processing Time, min:sec (range)
LIDO	1:38 (0:32-3:15)	6:42 (4:31-9:30)	2:49 (2:01-3:50)	5:18 (4:54-5:43)
CONT	0:30 (0:25-0:42)	6:39 (4:43-7:44)	3:24 (1:33-4:41)	4:42 (4:20-5:04)