



## Long-term weight gain and economic impact in pigs castrated under local anaesthesia



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### ABSTRACT

Castration is a controversial practice in swine production because in some countries is still performed without anaesthesia, and therefore causes intense suffering and stress to animals. This study investigated the effect of pre-surgical administration of local anaesthesia (LA) on the growth performance of piglets until the end of the growth phase (102 days). Piglets aged 3 to 5 days were selected in pairs of similar weights and same age. They were originated from 22 litters. The groups were randomly assigned to one of two treatments. Castration was performed with (LA;  $n = 45$ ) or without (NLA;  $n = 45$ ) intra-testicular administration of 0.5 mL of 2% lidocaine plus adrenaline per testicle, administered by an automatic repeating vaccinator. Castration was performed 10 min later. Average daily weight gain and economic impact were evaluated between the intervals before castration until 21 (weaning phase), before castration until 60 (end of the initial nursery phase) and before castration until 102 (growth phase) days of age. Average daily weight gain data were analyzed by comparing the average daily weight gain between the weaning phase, 60 and 102 days of age versus the initial weight (pre-castration). At the end of the growing phase, animals treated with LA showed greater weight gain than animals castrated without anaesthesia. LA also showed improved cost:benefit ratio and there might provide greater economic benefit under the conditions used in this study. Our findings have proved that castration with LA improves long-term weight gain of piglets.

### 1. Introduction

Castration avoids 'boar taint', caused by compounds such as androstenone and skatole, which give the meat an offensive odour. However, castration is one of the most controversial management practices in swine production, because it is usually performed without the use of perioperative anaesthetics and/or analgesics (McGlone & Hellman, 1988; Hansson, Lundeheim, Nyman, & Johansson, 2011; Kluivers-Poodt et al., 2012), and therefore causes intense suffering and stress to animals. Castration induces behavioral (Hansson et al., 2011, Kluivers-Poodt et al., 2012, Kluivers-Poodt, Zonderland, Verbraak, Lambooj, & Hellebrekers, 2013), biochemical and endocrine (Kluivers-Poodt et al., 2012; Sutherland, Davis, Brooks, & Coetzee, 2012) changes. Although these changes may be minimized by LA and analgesia (Hansson et al., 2011; Kluivers-Poodt et al., 2012, 2013), this is not yet a common practice worldwide.

Although intratesticular administration of local anaesthesia may cause a painful additional stimulus to castration, Haga and Ranheim (2005) have shown that administration of lidocaine intratesticularly or in the spermatic cord in piglets was effective in reducing the nocicep-

tive effects caused by orchietomy.

Over the years, many studies have been developed to reduce or prevent the stressful effects of surgical castration in pigs. However, the major obstacles to implementation of developed techniques in the industry are usually related to the economic impact or need of specialized technicians, which are not available in pig farms (De Roest, Montanari, Fowler, & Baltussen, 2009).

Although the current belief is that there is no difference in growth performance (i.e. weight gain) between pigs castrated with anaesthesia and those castrated without anaesthesia (McGlone & Hellman, 1988; Hansson et al., 2011; Kluivers-Poodt et al., 2012, 2013), the studies carried out to date have assessed this only for a short time, specifically for about 60 days (until the nursery production phase). It is not certain that use of LA would not improve weight gain in a later phase, therefore the novelty of this study is comparing the weight gain during the full growing phase of pigs castrated with or without anaesthesia, by proposing a practical and feasible technique under field circumstances.

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## 2. Material and methods

All of experimental procedures have been previously approved by the Animal Ethics Committee of this institution (CEUA), under protocol number 76/2013. The study was performed at a commercial farm. A total of 90 male commercial crossbreed (Landrace-Large White) piglets were divided into two groups of 45 piglets each. They were originated from 22 litters and piglets from each group were selected in pairs of similar weights and same age and maintained in the same pen. The number of piglets in each pen ranged from 4 to 8. After that, they were randomly assigned to one of the treatments. In the LA group, pigs underwent castration with LA, provided by intra-testicular administration of 0.5-mL of 2% lidocaine with adrenaline per testicle, administered by an automatic repeating vaccinator. The time for application of the anaesthetic was 25 s from the moment the animal was restrained to the moment it was released. Castration was performed 10 min later. In the NLA group, animals were castrated without LA. Animals were weighed immediately before surgery when piglets were between 3 and 5 days old, at weaning (21 days old), when they were 60 days old and at the end of growth phase (102 days old). The average daily weight gain (ADWG) was calculated according to:  $ADWG = [(Weight\ at\ weaning\ or\ at\ 60\ days\ of\ age\ or\ at\ the\ end\ of\ growth\ phase) - (Weight\ before\ surgery)] / (days\ between\ weight\ measurements)$ .

### 2.1. Statistical analysis

Average daily weight gain data were analyzed by comparing the average daily weight gain between the weaning phase, 60 and 102 days of age (final weights) versus the initial weight (pre-castration). Data were submitted to the PROC MIXED of SAS statistical package, using the RANDOM command to analyze the effects of random and REPEATED for the analysis of repeated measures. The following effects were considered: the effects of treatment, litter and phases (time point), as well as interactions between treatments and litters, treatments and phases, and litters and phases, depending on the daily weight gain response variable. Statistical significance was set as  $P < 0.05$ .

### 2.2. Economic impact

The economic impact was analyzed by a profit indicator (Mishan & Quah, 2007), based on the cost/benefit calculation, where cost was the value of the anaesthetic used for each animal plus the additional cost to pay the extra labour time for administration of lidocaine and benefit was the difference on weight (kg) between two groups, multiplied by the value of the pig weight (kg) in our region. Therefore, the result was obtained by the formula:

$$\text{Cost-benefit ratio} = \frac{\text{Weight difference between groups} \times \text{Value of 1 kg of live pig}^*}{\text{Costs}}$$

The price of one kilogram of pig was obtained at the Center for Advanced Studies in Applied Economics–CEPEA ESALQ (2016).

In this mathematical model, when the ratio is  $> 1$ , there is benefit; when the ratio = 1, the cost and benefit are the same; and when the ratio is  $< 1$ , the cost outweighs the benefit.

## 3. Results

There was a significant difference between two treatment groups at repeated measures for ADWG ( $p = 0.0155$ ). Based on slice analysis the ADWG between 102 days and before surgery was greater in LA group than in the NLA group ( $p = 0.0014$ ) (Table 1). The cost/benefit index considering the period before and 102 days was 11.05, indicating that implementation of this practice would be economically advantageous in

**Table 1**

Average daily weight gain with (LA) or without (NLA) local anaesthesia before and 21, 60 and 102 days of age.

	Mean (kg)		SEM	p value
	LA	NLA		
Time Point				
Before-21 days	0.191 <sup>a</sup>	0.174 <sup>a</sup>	0.0026	0.1040
21–60 days	0.319 <sup>a</sup>	0.310 <sup>a</sup>	0.0048	0.0972
60–102 days	0.549 <sup>a</sup>	0.529 <sup>b</sup>	0.0049	0.0354

SEM: Standard error of mean.

Mean values with same letter (line) are not significantly separated ( $p > 0.01$ ).

our region.

## 4. Discussion

This study demonstrates that use of local anaesthetic (LA) prior to castration appears to have positive effects on long-term weight gain of pigs, indicating that technique has both welfare for pigs and economic benefits for producers.

In the current study, long-term weight gain was improved when piglets at young age were castrated with LA. Although previous studies have reported that weight gain did not differ when castration was performed with LA, those studies evaluated weight gain only for a short period, and therefore did not address the long-term influence of pain due to castration (McGlone & Hellman, 1988; Hansson et al., 2011), which needs to be taken into account, given the productive cycle of animals. We did not observe any significant differences in weight gain until the end of nursery phase, when piglets were 60-day-old, as previously reported (Hansson et al., 2011; Kluivers-Poodt et al., 2012, 2013).

It has been widely reported that there is compensatory weight gain in pigs undergoing stress-induced feed restriction (Kristensen et al., 2002). Thus, it could be expected that a similar finding would be observed in pigs undergoing stress-induced castration; however, this was not the case in the current study. Thus, we believe that the pain induced by castration might elicit long-term neurophysiological changes, such as allodynia, hyperesthesia, hyperalgesia, paresthesia, or hyperpathia and possibly peripheral and/or central sensitization, which would have negative effects on weight gain, besides that, the results have indicated that these effects were reduced by LA (Prunier et al., 2006; Kluivers-Poodt, Hopster, & Spoolder, 2007). Although the expected anaesthetic effect of lidocaine with epinephrine in our study would be between 1- and 2-hour (White et al., 1995; Haga & Ranheim, 2005; Kluivers-Poodt et al., 2012), based on previous studies in men (Giannoni, White, Enneking, & Morey, 2001; Nguyen et al., 2001; Ong, Lirk, Seymour, & Jenkins, 2005; Katz & McCartney, 2005), we have hypothesized that the LA would produce a preventive analgesia and avoid peripheral and central sensitization, contributing to improve weight gain (Prunier et al., 2006).

Several systematic reviews and meta-analysis have defined and addressed the advantages of preventive analgesia in men (Ong et al., 2005; Katz & McCartney, 2005) and could explain our results. Pre-operative analgesic treatment, when compared to placebo, reduces pain for a longer time than the duration effect of analgesics as widely reported (Giannoni et al., 2001; Nguyen et al., 2001). The peritoneal infiltration of ropivacaine reduced tonsillectomy pain for up to 5 days post-operatively. In another study, local wound infiltration of ropivacaine, but not saline, decreased pain scores for 24-h after craniotomy (Nguyen et al., 2001). These and other studies have evidenced that preventive analgesia may diminish peripheral and central sensitization, originated from a noxious transoperative and postoperative input and reduce primary and secondary hyperalgesia (Lavand'Homme, 2006).

Numerous studies have examined the behavioral, biochemical and

endocrine changes occurring in response to castration in pigs, and have reported increases in cortisol, blood glucose and creatine kinase levels (Kluivers-Poodt et al., 2012; Sutherland et al., 2012), regardless of the use of intravenous (McGlone & Hellman, 1988) or inhalation anaesthesia, such as CO<sub>2</sub> (Sutherland et al., 2012). However, once animals are awake after intravenous or inhalation anaesthesia, peripheral and/or central sensitization may develop, and thus result in hypersensitivity of scrotal tissue (Kluivers-Poodt et al., 2007). Although previous studies have failed to detect any beneficial effects of LA in weight gain during castration in pigs (Hansson et al., 2011; Kluivers-Poodt et al., 2012, 2013), this study showed that there is a beneficial long term effect of LA in weight gain. In previous studies LA have minimized behavioral (McGlone & Hellman, 1988; Hansson et al., 2011; Kluivers-Poodt et al., 2013) and endocrine changes (Kluivers-Poodt et al., 2012). It is possible to speculate that behaviour might alter feed intake and cortisol might interfere in metabolism and therefore modify weight gain.

A relevant point is that any implemented technique under commercial circumstances should be easy to administer and preferentially with no need of specialized technicians. In this study, animals were handled for one additional time and LA anaesthesia was administered by an automatic repeating vaccinator, which can be used in a large scale. In Brazil, although the Federal Council of Veterinary Medicine does not recommend performing castration without anaesthesia, it is still allowed to perform castration without local anaesthesia specifically in newborn pigs. This procedure is commonly performed by technicians, and not veterinarians, like in other countries.

A limitation of the study was that the LA group animals were handled, and therefore subjected, to more stress than the NLA group. A control group with intra-testicular administration of 0.5-mL of saline solution administered at the same time and under the same conditions as the LA group would determine the stress effects of double handling and intra-testicular injection on results. However, when the experiment was designed, the authors decided to carry out the study simulating a situation as close as possible to real, by comparing either no anaesthesia, as is currently done in our circumstances, against local anaesthesia. Ideally, a further study could be performed to determine the stress effects of double handling and saline injection.

Considering that no disposable syringes and needles were used, as all injections were performed by an automatic repeating vaccinator, which is commonly available at the pig farms, the cost of this equipment has not been included as it would not be an extra cost. The cost/benefit analysis has suggested that LA prior to castration of pigs might be feasible on a larger production scale to improve profits. However, this analysis is restricted to our economic conditions and region, and, to be applicable in a larger context needs further investigation in other areas and conditions. The use of an automatic repeating vaccinator was essential to minimize time and cost of LA, and to optimize management during procedures. This is a simple method that might be used in further studies. Other limitations of this study were that feed intake and feed:gain ratios were not evaluated, so these data would be important to support economic impact. Unfortunately, we were not able to measure these parameters because of the experimental design used, where LA and NLA animals were paired at the same pen to provide the same environment conditions as described in material and methods.

Another limitation of present study was that other indicators of welfare, such as behavioral, endocrine and biochemical changes were not measured; if they had been done, they might have contributed to the discussion of results.

There is a strong ethical debate about use of anaesthesia for pig castration and the present paradigm is that there is no beneficial in weight gain, when pigs are castrated with anaesthesia (McGlone & Hellman, 1988; Hansson et al., 2011; Kluivers-Poodt et al., 2012, 2013). However these studies did not perform a long term evaluation, as weight gain was investigated only in the maximum 60 days

(McGlone & Hellman, 1988; Hansson et al., 2011; Kluivers-Poodt et al., 2012, 2013).

Although, there are behavioral, biochemical and endocrine changes related to castration in pigs (McGlone & Hellman, 1988; White et al., 1995; Hansson et al., 2011) and, even for the public, it is apparently obvious that pigs feel pain, there is still a resistance in alleviating pain in farm animals, especially in pigs. According to a Canadian study, less than 0.001% of Veterinarians use analgesics for pig castration (Hewson, Dohoo, Lemke, & Barkema, 2007). Possible reasons of low use of analgesics in pigs may be related to small profit gain and that herd, rather than individuals, is considered (Hewson et al. 2007). Even in Norway where the practice of anaesthesia has been implemented for castration, only about two thirds of Veterinarians, against one third of the farmers, were satisfied with the policy (Fredriksen & Nafstad, 2006).

The present study may change the paradigm that is economically unviable to castrate pigs with anaesthesia, by showing that there is a potential economical advantage in castrating pigs with local anaesthesia, particularly among pig producers, as 66% of them “think the animals’ welfare does not improve with castration with anaesthesia, given that the animals are more stressed preceding the castration” and 50% totally agree that “castration of pigs is a very old practice which is well endured by the animals” (Tuytens, Vanhonacker, Verhille, De Brabander, & Verbeke, 2012).

In contrast to the producer’s opinion, 77% of Norwegian consumers considered castration without anaesthesia not acceptable (Fredriksen, Johnsen, & Skuterud, 2011).

The debate of alternatives to castration requires a profound discussion about meat quality, economic viability, degree of technification and animal welfare. Thus, the rationale guided in economic benefit to the production can be a great ally for global changes, particularly in regions where castration is practiced without anaesthesia and the legislation will take a long time to be adjusted, according to the ethical precepts of each locality.

## 5. Conclusion

Taking into account the growing concern of consumers and researchers regarding the improvement of animals’ welfare applied on food chain, the current belief that LA is not beneficial in pigs undergoing castration warrants further investigation, by measuring weight gain until slaughter. Pigs subjected to orchietomy under LA showed greater weight gain during growing phase compared to castrated pigs without LA, demonstrating that acute pain due to castration might interfere on long-term weight gain. Therefore, considering both point of view of animal welfare and production, we recommend the use of local anaesthesia in piglets submitted to castration.

## Conflict of interest

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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## References

- Centro de Estudos Avançados em Economia Aplicada (2016). CEPEA – ESALQ/USP. Suíno [cited 2016 Mar 29]. [online]. Available from (<http://cepea.esalq.usp.br/suino>)
- De Roest, K., Montanari, C., Fowler, T., & Baltussen, W. (2009). Resource efficiency and

- economic implications of alternatives to surgical castration without anaesthesia. *Animal*, 3(11), 1522–1531.
- Fredriksen, B., Johnsen, A. M. S., & Skuterud, E. (2011). Consumer attitudes towards castration of piglets and alternatives to surgical castration. *Research in Veterinary Science*, 90(2), 352–357.
- Fredriksen, B., & Nafstad, O. (2006). Surveyed attitudes, perceptions and practices in Norway regarding the use of local anaesthesia in piglet castration. *Research in Veterinary Science*, 81(2), 293–295.
- Giannoni, C., White, S., Enneking, F. K., & Morey, T. (2001). Ropivacaine with or without clonidine improves pediatric tonsillectomy pain. *Archives of Otolaryngology – Head & Neck Surgery*, 127(10), 1265–1270.
- Haga, H. A., & Ranheim, B. (2005). Castration of piglets: The analgesic effects of intratesticular and intrafunicular lidocaine injection. *Veterinary Anaesthesia and Analgesia*, 32, 1–9.
- Hansson, M., Lundeheim, N., Nyman, G., & Johansson, G. (2011). Effect of local anaesthesia and/or analgesia on pain responses induced by piglet castration. *Acta Veterinaria Scandinavica*, 53, 34.
- Hewson, C. J., Dohoo, I. R., Lemke, K. A., & Barkema, H. W. (2007). Canadian veterinarians' use of analgesics in cattle, pigs, and horses in 2004 and 2005. *Canadian Veterinary Journal*, 48(2), 155.
- Katz, J., & McCartney, C. J. L. (2002). Current status of pre-emptive analgesia. *Current Opinion in Anesthesiology*, 15(4), 435–441.
- Kluyvers-Poodt, M., Hopster, H., & Spoolder, H.A.M. (2007). Castration under anaesthesia and/or analgesia in commercial pig production. Report 85. *Animal Sciences Group, Wageningen-UR, The Netherlands*
- Kluyvers-Poodt, M., Houx, B. B., Robben, S. R. M., Koop, G., Lambooi, E., & Hellebrekers, L. J. (2012). Effects of a local anaesthetic and NSAID in castration of piglets, on the acute pain responses, growth and mortality. *Animal*, 6, 1469–1475.
- Kluyvers-Poodt, M., Zonderland, J. J., Verbraak, J., Lambooi, E., & Hellebrekers, L. J. (2013). Pain behaviour after castration of piglets; effect of pain relief with lidocaine and/or meloxicam. *Animal*, 7, 1158–1162.
- Kristensen, M., Therkildsen, B., Riis, M. T., Sørensen, N., Oksbjerg, P., Purslow, P., & Ertbjerg, P. (2002). Dietary-induced changes of muscle growth rate in pigs: Effects on in vivo and post mortem muscle proteolysis and meat quality. *Journal of Animal Science*, 80, 2862–2871.
- Lavand'Homme, P. (2006). Perioperative pain. Pain medicine. *Current Opinion in Anaesthesiology*, 19, 556–561.
- McGlone, J. J., & Hellman, J. M. (1988). Local and general anesthetic effects on behavior and performance of two and seven-week-old castrated and uncastrated piglets. *Journal of Animal Science*, 66, 3049–3058.
- Mishan, E.J., & Quah, E. (2007). Cost benefit analysis (5th ed.) Routledge, Abingdon, Oxfordshire, UK
- Nguyen, A., Girard, F., Boudreault, D., Fugere, F., Ruel, M., Mounmdjian, R., Bouthilier, A., Caron, J. L., Bojanowski, M. W., & Girard, D. C. (2001). Scalp nerve blocks decrease the severity of pain after craniotomy. *Anaesthesia & Analgesia*, 93(5), 1272–1276.
- Ong, C. K. S., Lirk, P., Seymour, R. A., & Jenkins, B. J. (2005). The efficacy of preemptive analgesia for acute postoperative pain management: A meta-analysis. *Anaesthesia & Analgesia*, 100(3), 757–773.
- Prunier, A., Bonneau, M., von Borell, E. H., Cinotti, S., Gunn, M., Fredriksen, B., Giersing, M., Morton, D. B., Tuytens, F. A. M., & Velarde, A. (2006). A review of the welfare consequences of surgical castration in piglets and evaluation of non-surgical methods. *Animal Welfare*, 15, 277–289.
- Sutherland, M. A., Davis, B. L., Brooks, T. A., & Coetzee, J. F. (2012). The physiological and behavioral response of pigs castrated with and without anaesthesia or analgesia. *Journal of Animal Science*, 90, 2211–2221.
- Tuytens, F. A., Vanhonacker, F., Verhille, B., De Brabander, D., & Verbeke, W. (2012). Pig producer attitude towards surgical castration of piglets without anaesthesia versus alternative strategies. *Research in Veterinary Science*, 92(3), 524–530.
- White, R. G., DeShazer, J. A., Tressler, C. J., Borchert, G. M., Davey, S., Waninge, A., Parkhurst, A. M., Milanuk, M. J., & Clemens, E. T. (1995). Vocalization and physiological response of pigs during castration with or without a local anesthetic. *Journal of Animal Science*, 73, 381–386.