Anaesthesia for castration of 2–8 day old piglets using dexmedetomidine-alfaxalone with or without butorphanol or pethidine

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Anästhesie zur Kastration von Ferkeln im Alter von 2–8 Tagen mit Dexmedetomidin-Alfaxalon mit oder ohne Butorphanol oder Pethidin

Die derzeitige intramuskuläre Anästhesie mit Azaperon und Ketamin bei der Ferkelkastration ist hinsichtlich Anästhesie und Aufwachphase unbefriedigend. Ziel dieser Studie war die Evaluierung verschiedener intramuskulärer Medikamentenkombinationen, um eine Anästhesie ohne Abwehrbewegung oder Lautäusserungen während des Eingriffs zu erreichen. Gleichzeitig sollte eine periphere kapillare Sauerstoffsättigung (SpO_2) von >90 % aufrechterhalten werden und Erregungszustände während Einleitung und Aufwachphase vermieden werden. Die Ferkel sollten innerhalb von zwei Stunden nach der Medikamentenverabreichung aufstehen.

Den 19 Ferkeln wurden 2 mg/kg Alfaxalon und 25 µg/kg Dexmedetomidin verabreicht. Bewegten sich während der Operation zwei aufeinanderfolgende Ferkel, wurde die Dosierung entsprechend einem vorher festgelegten Schema erhöht, mit Maximaldosen von 6 mg/kg Alfaxalon und 40 µg/kg Dexmedetomidin. Im Falle einer Reaktion auf ein Kneifen des Nasenseptums vor der Operation wurden 4 mg/kg Lidocain 2 % intratestikulär injiziert. Trotz örtlicher Betäubung oder ausbleibender Reaktion auf das Kneifen des Nasenseptums was auf eine ausreichende Narkosetiefe hindeutet, reagierte nur ein Ferkel nicht auf die Quetschung des Samenstrangs. Folglich erhielten weitere 12 Ferkel nach dem Zufallsprinzip 40, 50 oder 60 µg/kg Dexmedetomidin und 5 mg/kg Alfaxalon, mit oder ohne 0,2 mg/kg Butorphanol. Nur ein Ferkel bewegte sich nach der Behandlung mit Butorphanol und 40 µg/kg Dexmedetomidin während der Operation nicht. Daher erhielten weitere acht Ferkel 40 µg/kg Dexmedetomidin, 5 mg/kg Alfaxalon und 4 mg/kg Pethidin. Auch alle diese Ferkel reagierten auf die Kastration, und die Sauerstoffsättigung lag unter 90 %. Es wurden keine weiteren Tests durchgeführt.

Summary

Current intramuscular anaesthesia for piglet castration, involving azaperone and ketamine, is unsatisfactory in terms of anaesthesia and recovery. This study aimed to evaluate different intramuscular drug combinations to achieve anaesthesia without movement or vocalisation during surgery, while maintaining haemoglobin oxygen saturation (SpO_2) >90 % and excitation-free induction and recovery, with piglets standing within two hours of drug administration.

Alfaxalone and dexmedetomidine were administered to 19 piglets at starting doses of 2 mg/kg and 25 µg/kg, respectively. If two consecutive piglets moved during surgery, the doses were increased based on a predetermined dosage tree, with maximum doses of 6 mg/kg alfaxalone and 40 µg/kg dexmedetomidine. In case of reaction to presurgical nose pinch, 4 mg/kg lidocaine 2 % was injected intratesticulary. Despite local anaesthesia or no reaction to nose pinch indicating sufficient depth of anaesthesia, only one piglet did not react to spermatic cord crushing. Consequently, another 12 piglets, randomly received 40, 50 or 60 µg/kg dexmedetomidine and 5 mg/kg alfaxalone, with or without butorphanol 0,2 mg/kg. Only one piglet, after butorphanol and 40 µg/kg dexmedetomidine, did not move during surgery. Therefore, another eight piglets received 40 µg/kg dexmedetomidine, 5 mg/kg alfaxalone and 4 mg/kg pethidine. However, all piglets reacted to surgery, and SpO_2 was below 90 %. No further testing was conducted.

In conclusion, none of the tested combinations of alfaxalone and dexmedetomidine, whether with or without an opioid, provided satisfactory anaesthesia for surgical castration in piglets aged between two and eight days.

Keywords: boar, pig, castration, analgesia, hypnosis

Zusammenfassend lässt sich sagen, dass keine der getesteten Kombinationen von Alfaxalon und Dexmedetomidin, weder mit noch ohne Opioid, eine zufriedenstellende Anästhesie für die chirurgische Kastration von Ferkeln im Alter zwischen zwei und acht Tagen ermöglichte.

Schlüsselwörter: Eber, Schwein, Kastration, Analgesie, Hypnose

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Introduction

Although alternatives exist, castration of piglets is common practice in the European swine industry in order to prevent «boar taint» of the meat.[17] Castration is a painful procedure and welfare of the animals is a major concern (https://www.belganewsagency.eu/despite-intention-to-end-piglet-castration-it-remains-a-common-eu-welfare-violation); many European countries have legislated for mandatory anaesthesia and analgesia for piglet castration.[17]

As the pig industry is not ready for alternative methods of piglet castration, it is imperative to improve on the current common practice of injectable general anaesthesia with ketamine-azaperone. This combination does not provide satisfactory analgesia and often results in a stormy prolonged recovery which is extremely stressful for the piglets.[5,7,25] This method also results in an unacceptably high number (4 %) of deaths,[15] probably as a result of postoperative hypo- or hyperthermia[25] caused by azaperone. It is also possible that lethargy continues after anaesthesia when the piglets have been returned to the sow[26] which ultimately is life threatening for very young piglets. The use of ketamine in Europe and Switzerland requires veterinary supervision, increasing the cost and incurring logistical challenges. There is also growing concern that increased use of ketamine might contribute to the growing number of young adults abusing ketamine (https://www.newportinstitute.com/resources/co-occurring-disorders/ketamine-use-young-adults/). Addition of the alpha$_2$-adrenoreceptor agonist romifidine to the current azaperone-ketamine protocol leads to better anaesthesia quality but unacceptably long recovery.[21] To provide better analgesia for castration the opioid butorphanol was also tested successfully.[18]

In order to address the need for improved injectable anaesthesia for piglet castration investigations were carried out in Germany comparing azaperone-ketamine and a non steroidal anti inflammatory drug (NSAID) (meloxicam) with isoflurane inhalation anaesthesia combined with meloxicam. These studies concluded that, from an animal welfare perspective, inhalation anaesthesia should be prioritised.[1] Recovery from isoflurane anaesthesia is very rapid (within a few minutes) and farmers are permitted to use this method without the direct supervision of a veterinarian. Although another investigation concluded that none of the available regimes resulted in completely pain free castration,[20] both European and Swiss laws permit isoflurane in combination with meloxicam for analgesia; this combination is now used in the majority of cases in Switzerland (about 90 %) and Germany (about 80 %) (https://ilvo.vlaanderen.be/en/dossiers/alternatives-to-castration-of-male-piglets).

Isoflurane is a known greenhouse gas with a significant effect on global warming, due to its accumulation in the atmosphere.[28] Hence there is a strong argument for ceasing its use for piglet castration. In spite of efforts to recycle anaesthetic agents, the environmental impact of these gases is of major concern, particularly when millions of piglets in Europe are castrated under isoflurane anaesthesia. Alternative methods that are safe for the piglets, easy to perform for the farmer and result in pain free castration should be sought.

Local anaesthesia, for example intra testicular lidocaine, reduces pain but does not eliminate intraoperative nociception entirely[9] so the whole process still causes considerable stress to the animals.[13] Even the combination of local anaesthesia with meloxicam, the NSAID commonly used in piglets, did not yield satisfactory results from an animal welfare perspective.[14] Alfaxalone is the only anaesthetic other than ketamine which can be administered intramuscularly (IM). It is primarily a hypnotic drug. In dogs it was successfully used to induce anaesthesia in 12 week old puppies[19] but it has also been shown not to provide analgesia following anaesthesia.[2] In 2–10 day old piglets intra testicular administration of 4–8 mg/kg alfaxalone combined with lidocaine resulted in anaesthesia within 2–3 minutes and recovery within 30–35 minutes.[8] However, 23 % of the piglets shook and twitched during anaesthesia induction and made purposeful movement during castration. Unfortunately, the incidence of these movements was not reported.

Dexmedetomidine is a very potent and specific alpha$_2$-adrenoreceptor agonist which provides sedation and pain relief and appears ideal for combination with alfaxalone. Use of medetomidine, a racemic mixture containing 50 % dexmedetomidine, has been reported in pigs and doses of 30–150 mcg/kg IM were shown to induce deep sedation within 10 minutes.[23] The combination of 10 mcg/kg dexmedetomidine and 5 mg/kg alfaxalone led to lateral recumbency within 150–248 seconds in two-month-old piglets

and sedation was deeper with alfaxalone than with the combination of dexmedetomidine and 10 mg/kg ketamine.[24]

The purpose of our study was to establish an anaesthestic protocol suitable for use «in the field» that would produce satisfactory anaesthesia after a single intramuscular injection in piglets undergoing castration. Satisfactory anaesthesia entailed no movement during surgery, adequate oxygenation, excitation-free induction and recovery and piglets standing within two hours of drug administration. The aim was to establish dose rates of alfaxalone combined with dexmedetomidine to achieve such anaesthesia and compare this combination with the current standard azaperone-ketamine protocol.

Materials and Methods

The study was conducted by the Section of Anaesthesiology, Department of Clinical Diagnostics and Services, Vetsuisse Faculty, University of Zürich. The project was partially funded by Carus Animal Health Limited, High Wycombe, Bucks, England.

The research comprised three trials conducted at the University of Zurich's Tierspital. The first trial was designed according to the initial study aim, namely, to find a suitable dose of alfaxalone and dexmedetomidine for piglet castration without reaction (purposeful movement or vocalisation) to surgical intervention, no desaturation of hemoglobin (e.g. hemoglobin saturation >90 %) during anaesthesia and complete recovery within 2 hours of drug administration. The subsequent investigations were adjusted according to the results of the preceding trials. To compensate for the apparent lack of analgesia the use of additional butorphanol (trial 2) or pethidine (trial 3) was studied in the following trials.

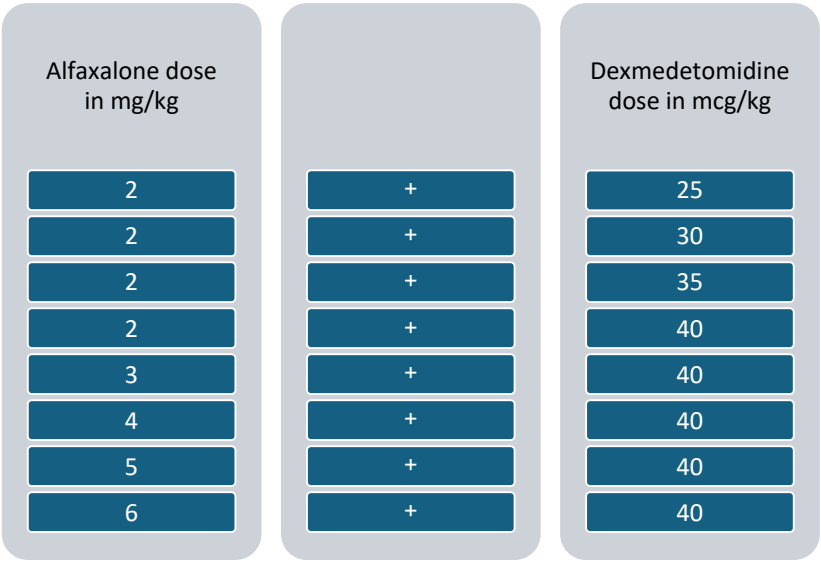

Figure 1: Dosage tree. From top to bottom: dose rates used in an ascending manner for anaesthesia to castrate 2–8 day old piglets using dexmedetomidine-alfaxalone. If anaesthesia for castration in the preceding case was deemed insufficient in two consecutive piglets (e.g. reaction to nose pinch before castration five and ten minutes following intramuscular drug administration or purposeful movement during castration necessitating administration of intratesticular lidocaine), the next higher dose was tested.

Animal experimentation licences

The study was approved by the ethics representatives of the University of Zürich and subsequently by the Veterinäramt of the Canton of Zürich, in accordance with Swiss regulations. As the tested drugs were not approved for use in food-producing animals, additional approval was obtained by the Bundesamt für Landwirtschaft und Veterinärwesen (BLV).

Animals and preparation for anaesthesia

Thirty-nine male 2–8 day old piglets from the University of Zurich were studied. In all trials, twenty minutes before induction of anaesthesia, the piglets were separated from their litter, weighed, labelled with coloured numbers on their backs, and 0,4 mg/kg meloxicam IM was administered in the neck. They were then left undisturbed in the litter box. To prevent stress, piglets were never left alone, either before or after anaesthesia; thus, two piglets were injected IM at the same time. If there was an odd number of piglets in a litter the last three were injected together.

One individual not involved in assessment was responsible for preparing the drugs. In the first trial three evaluators and the surgeon (always the same) were aware that escalating doses of azaperone and dexmedetomidine were administered to the piglets so they were not blinded to treatment; in the consecutive trials they were all blinded.

Anaesthesia assessment

The goal was to achieve satisfactory anaesthesia after a single IM injection of the anaesthetic combination. The outcome was either success: surgery performed with no movement or need to give lidocaine, or failure: movement of head, limbs or tail, vocalisation and need for administration of local anaesthetic before or during surgery. Drug doses in the first experiments were administered in an ascending dose manner according to a predetermined dosage tree (Figure 1).

After IM injection of the anaesthetic drugs, the piglets were left undisturbed in the litter box, under continuous observation and were videotaped. After 5 minutes, their nasal septum was pinched (always by the same investigator). If there was no reaction, castration was performed immediately. If there was a reaction to nose pinch (any purposeful movement), another 5 minutes elapsed before retesting. If there was no reaction after the additional 5 minutes, surgery was commenced. For piglets which still reacted to nose pinch 10 minutes after drug administration, 4 mg/kg lidocaine 2 % was injected into each testicle, and then one minute later surgery was performed.

Unsatisfactory surgical conditions (movement of head, limbs, or tail and/or vocalisation in response to surgery) were considered to indicate inadequate analgesia; poor relaxation and spontaneous movement was considered lack of hypnosis. In both cases the tested dose was considered a «failure» and local anaesthesia with intratesticular lidocaine 2 % (4 mg/kg/testes) provided. Nevertheless, the piglets were constantly observed and recovery scored.

Drugs and dose rates tested

In **trial 1** combinations of dexmedetomidine in combination with alfaxalone were tested. Dose rates were chosen according to a dosage chart (Figure 1) created based on the literature cited above and the consensus of the anaesthetists involved in the study. The first two piglets received 25 mcg/kg dexmedetomidine mixed with 2 mg/kg alfaxalone IM. If surgical conditions were unsatisfactory in two consecutively castrated piglets (indicating inadequate analgesia), the doses for the subsequent piglets were adjusted upwards according the dosage chart (Figure 1) and the next (higher) dose was administered to the next piglets (Figure 1). Successful castration without movement or need to give lidocaine, adequate oxygenation during surgery and recovery to standing within 2 hours would be considered a «success». The dose leading to «success» would then be administered to the remaining piglets of a litter and consecutively blindly tested in a second experiment to compare it with the standard ketamine and azaperone protocol.

As escalating maximal doses of dexmedetomidine and alfaxalone leading to a complete recovery within 2 hours, failed to produce satisfactory anaesthesia (i.e. «success» meaning no purposeful reaction to surgery, no need to administer local lidocaine), the initial plan, to compare it blindly to the standard anaesthesia combination for piglet castration (azaperone and ketamine) was aborted.

In an attempt still to find a successful drug combination in **trial 2**, inclusion of the opioid analgesic butorphanol, to improve the level of analgesia, was assessed. Twelve piglets were randomly assigned to receive 40, 50 or 60 mcg/kg dexmedetomidine mixed with 5 mg/kg alfaxalone IM, representing dose rates that were identified in trial 1 as potentially sufficient to meet the predefined requirements for satisfactory anaesthesia. Piglets receiving 40 mcg/kg dexmedetomidine also received 0,2 mg/kg butorphanol. Piglets receiving 50 or 60 mcg/kg dexmedetomidine IM were randomly assigned to receive 0,2 mg/kg butorphanol IM or no butorphanol. The need for lidocaine administration was considered to indicate lack of analgesia and was deemed failure as in trial 1.

In **trial 3** inclusion of pethidine (a more efficacious opioid then butorphanol)[27] was evaluated in response to the trial 2 piglets appearing deeply anaesthetised (hypnosis) but still responding to surgery (poor pain relief). All trial 3 piglets received 4 mg/kg pethidine together with 5 mg/kg alfaxalone and 40 mcg/kg dexmedetomidine IM. The piglets were simply observed in an attempt to evaluate the potential value of further dose efficacy/safety studies with the combination of alfaxalone-dexmedetomidine and pethidine.

Observations and decisions taken

All steps of the castration process were videotaped and assessed. The predetermined criteria that had to be met, in order to consider a drug dosage suitable for further evaluation (ie a «success») were: excitation-free induction of anaesthesia, no reaction to surgical stimulation (defined as no movement of head, limbs or tail) and calm recovery from anaesthesia, completed within 2 hours. Three independent observers judged the suitability of a dose regime during castration (eg. drug regime meets predetermined criteria or not). In trial 1, the observers were aware of the treatment protocol and not «blinded observers». Therefore, after the first set of experiments, castrations were reassessed from videotapes in a random order by the same observers now blinded to treatment dose rates administered.

If, during anaesthesia induction or recovery, two piglets at any dose rate showed paddling (for longer than 15 secs) or excitation this was recorded and considered as «failure».

Castration

When anaesthesia was considered sufficient and the piglets did not react to nose pinch, they were restrained on their backs and the area over both testicles was disinfected with an antiseptic solution. The skin over the testicle was incised, the testicle advanced, and the spermatic cord crushed. The wound was then sprayed with antiseptic.

If ten minutes after drug injection the piglets still reacted to nose pinch, the surgical field was prepared and 4 mg/kg lidocaine 2 % was injected into each testicle and after one minute the piglets castrated. If there was no reaction to nose pinch, but a clear reaction to skin cut (i.e. movement of limbs, head or tail, vocalisation) or crushing of the spermatic cord 4 mg/kg lidocaine 2 % was injected into each testicle before proceeding further with the surgery.

Oxygenation

Oxygenation during unconsciousness was evaluated using pulse oximetry (Masimo Radical 7, Masimo International SARL, Neuchatel). Oxygen haemoglobin saturation (SpO_2) above 90 % was considered sufficient. Any reading below 90 % was recorded and considered as «failure».

Recovery

After surgery, the piglets were returned to the litter box and placed under heating lamps.

All recoveries were videotaped and scored by one observer using a scoring system (Table 1).

A single episode of limb twitching or paddling lasting less than 15 seconds was considered acceptable if not followed or preceded by excitation or repeated attempts to stand followed by falling. The goal was a completed recovery (piglet standing and ambulatory) no more than 120 minutes after the IM injection of the anaesthetic combination.

Data management

All data and observations were recorded in Excel for further evaluation. Descriptive data only are presented.

Results

Trial 1

In the first trial, 19 Duroc x Edelschwein piglets from three different litters (mean body weight: 2,71 kg, SD 0,65 kg) were included. The mean time from IM injection of alfaxalone - dexmedetomidine to the first incision was 12 minutes (SD 1 minutes).

Results are shown in Table 2: Nine piglets injected with either 25 (n=2), 30 (n=2), 35 (n=2) or 40 mcg/kg (n=3) dexmedetomidine and 2 (n=8) or 3 (n=1) mg/kg alfaxalone IM reacted to nose pinch at 5 and 10 minutes and received 4 mg/kg intratesticular lidocaine for castration. Three piglets receiving 40 mcg/kg dexmedetomidine and 3 mg/kg alphaxalone IM did not react to nose pinch but required lidocaine during surgery as there was a clear purposeful reaction to the skin incision. Eight piglets after doses of 2 mg/kg alfaxalone and up to 40 mcg/kg dexmedetomidine and one piglet after 3 mg/kg alfaxalone and 40 mcg/kg dexmedetomidine reacted to crushing of the spermatic cord, even with local anaesthesia. Once a dose of 40 mcg/kg dexmedetomidine and 4 mg/kg alfaxalone was reached, there was no reaction to nose pinch.

Two piglets after 40 mcg/kg dexmedetomidine and 4 and 5 mg/kg alfaxalone and three piglets after 40 mcg/kg dexmedetomidine and 6 mg/kg alfaxalone did not react to nose pinch and were castrated without local anaesthesia. However, only one of these piglets (40 mcg/kg dexmedetomidine and 4 mg/kg alfaxalone, without local anaesthesia) reached the goal of acceptable anaesthesia defined as no purposeful movement during surgery and was deemed a «success».

All the piglets recovered reasonably smoothly within 2 hours. Recovery time to standing increased from 37 with the lowest doses to 78 minutes after the highest and took on average 56,1 minutes (SD 10,8 minutes). Observed median recovery scores (judged according to the scoring system in Table 1, independent of dosage administered) were: 1 for paddling (range 1–3), 0 for convulsions (range 0–0) and 1 for vocalization (range 0–2). Piglets took 2 (range 2–3) attempts to stand.

Table 1: Scoring system used to score recovery from anaesthesia in piglets recovering from castration receiving various intramuscular dose rates of alfaxalone-dexmedetomidine with or without 0,2 mg/kg butorphanol or 4 mg/kg pethidine.

Score	Rowing/paddling	Score	Convulsions	Score	Attempts to get up successfully	Score	Vocalisation
0	Not present	0	None	0	One attempt	0	None
1	Observed once	1	Observed once	1	2–3 attempts	1	Growling
2	Observed repetitively	2	Observed repetitively	2	4–6 attempts	2	Screeching once
3	Continuously observed (> 15 secs)	3	Continuously observed (> 15 secs)	3	> 6 attempts	3	Continuous screeching

Table 2: Results of **Trial 1:** Dosages of dexmedetomidine and alphaxalone and application of intratesticular lidocaine to 19 piglets and concomitantly observed reactions to nose pinch and surgery.

Alphaxalone dose (mg/kg)	Dexmedetomidine dose (mcg/kg)	Number of piglets tested	Reaction to nose pinch before surgery and concomitant intratesticular lidocaine	Reaction to surgery (limb movement / and or vocalization)
2	25	2	all positive	all positive
2	30	2	all positive	all positive
2	35	2	all positive	all positive
2	40	2	all positive	all positive
3	40	4	1 positive, 3 negative	1 negative
4	40	2	all negative	all positive
5	40	2	all negative	all positive
6	40	3	all negative	all positive

Oxygenation
Assessing oxygenation was challenging due to the limited duration of unconsciousness and the lack of deep hypnosis with lower anaesthetic dose rates. When good hypnosis was reached with the higher doses, pulse oximetry without artefacts became possible. However, measurements in the early stages of anaesthesia were still often unsuccessful. When successful measurements were achieved, SpO_2 remained above 90 %.

Other observations
During the induction of anaesthesia piglets given doses of 4 mg/kg alfaxalone or above exhibited short episodes of muscle twitching lasting up to 60 seconds.

Trial 2

Twelve Duroc X Edelschwein piglets from two different litters (mean weight 1,9 kg, SD 0,78 kg) were studied. All piglets received 5 mg/kg alfaxalone IM. In all cases the depth of anaesthesia (hypnosis) evidenced by good muscle relaxation and absence of reflexes to non noxious stimulation was judged as deep. However, analgesia was deemed poor, as the vast majority of piglets still made purposeful movements during castration, whether or not they had received butorphanol. Of the four piglets receiving 40 mcg/kg dexmedetomidine and 0,2 mg/kg butorphanol, two reacted to the nose pinch and received local anaesthesia. Only one piglet did not react to the surgical incision or spermatic cord tension and did not receive lidocaine («success»). Others in this group reacted (two slightly and one clearly) whether or not they received lidocaine. Four piglets received 50 mcg/kg dexmedetomidine, with only one also receiving 0,2 mg/kg butorphanol. The three receiving only dexmedetomidine all reacted to nose pinch and were treated with intra testicular lidocaine but still clearly reacted to the spermatic cord tension. The piglet that had received butorphanol still reacted slightly to spermatic cord tension.

Four piglets received 60 mcg/kg dexmedetomidine, with two also receiving 0,2 mg/kg butorphanol. The two not receiving butorphanol reacted to the nose pinch so local anaesthesia was given but they still reacted clearly to the incision. One piglet that had received butorphanol still reacted to the skin incision and the other reacted slightly when the spermatic cord was crushed.

All the piglets recovered smoothly within 2 hours. Recovery to standing took 46 to 112 minutes (mean 85 minutes, SD 31 minutes). Observed median recovery scores were: 1 for paddling (range 0 – 2), 0 for convulsions (range 0 – 0), 1 (range 0 – 3) for attempts to stand and 1 for vocalization (range 1 – 1).

Oxygenation
One piglet in each dexmedetomidine group developed short episodes (maximum 2 minutes) of SpO_2 < 90 % before surgery, with minimum values of 85 %.

Other observations
All piglets exhibited short episodes of muscle twitching lasting up to 60 seconds during anaesthesia induction.

Trial 3

Eight Duroc x Edelschwein x Landrace piglets from the same litter (mean weight 4,2 kg, SD 0,64 kg) received the same trial 3 dosing (4 mg/kg pethidine together with 40 mcg/kg dexmedetomidine and 5 mg/kg alfaxalone IM). Three piglets reacted to the first nose pinch and two of these also reacted to the second pinch, necessitating intra testicular lidocaine. All piglets exhibited limb movements and/or vocalization during tension on the spermatic cord, whether or not local anaesthesia had been administered. The two piglets that had received lidocaine before the start of surgery reacted similarly to those that did not receive lidocaine.

Oxygenation
All the piglets tested (n=8) had brief periods of SpO_2 < 90 %.

Recovery
Recovery was smooth and complete within 2 hours in all eight piglets. The first movements occurred at 45 – 84 minutes (mean 52 minutes) after IM anaesthetic administration, with all piglets standing within 55 – 100 minutes (mean 70 minutes).

Discussion

The present study aimed to identify a drug combination that produces satisfactory anaesthesia in piglets undergoing castration with a single IM injection. Satisfactory anaesthesia (a «success») was defined as free of movement during surgery, no detriment to vital function and maintenance of SpO_2 above 90 % (without oxygen supplementation) and smooth recovery to standing within 2 hours of drug administration. The drug dose rates chosen were based on those published previously[23,24] and titrated up to find a suitable combination.

Unfortunately, only 2 «successes» were achieved out of 39 cases: the study failed to identify a satisfactory anaesthetic drug combination to be given as a single IM injection that would be suitable for routine high throughput castration of young piglets. Extraction of the testes and crushing the spermatic cords are considered the most painful elements of piglet castration.[29] Almost all the piglets in our study reacted strongly to surgery even with the higher doses of the tested drug combinations.

Published reports suggested that alfaxalone doses above 4 mg/kg combined with dexmedetomidine at 40 mcg/kg and higher produced adequate anaesthesia for surgery in most piglets.[23,24] Bigby et al (2017)[3] evaluated 4 mg/kg alfaxalone, 40 mcg/kg medetomidine and 0,4 mg/kg butor-

phanol in 6–8 week old piglets and with a mean dose of only 0,9 mg/kg additional alfaxalone, endotracheal intubation was possible (three out of 12 piglets did not even need any additional alfaxalone). In older, heavier gilts (average 116 kg) and sows (average 242 kg) premedicated with IM azaperone (2,1 and 1,2 mg/kg respectively) an intravenous (IV) dose of only 0,9 and 0,7 mg/kg alfaxalone respectively allowed endotracheal intubation.[11]

Although both study design and coadministered drugs were different it appears that younger pigs require much higher drug doses to achieve satisfactory anaesthesia. Nevertheless, it is astonishing that, in our study, with high doses of two potent drugs (alfaxalone and dexmedetomidine) and the concomitant use of butorphanol, known to enhance sedation and provide analgesia,[22] most piglets clearly reacted to surgical manipulation. Even exchanging butorphanol for the more efficacious mu-receptor opioid analgesic pethidine[27] did not improve the quality of anaesthesia. Moreover, the pethidine combination led to unacceptable haemoglobin desaturation in all the piglets, indicating that enhancing the opioid contribution to analgesia was neither effective nor safe. A similar study in older boars (5 months old) castrated under sedation with detomidine-midazolam compared the administration of butorphanol (0,2 mg/kg) with morphine (0,2 mg/kg) and reported only mild respiratory depression with both opioids (mean PaO_2 70–82 mmHg)[16] but better analgesia with butorphanol. Butorphanol's superior analgesia over morphine is surprising; mu-receptor agonistic opioids (such as morphine and pethidine) are considered more efficacious analgesics compared to the kappa agonistic opioid butorphanol. Perhaps this is not the case for pigs.[16]

In cats, for instance, the same drug regime of alfaxalone, dexmedetomidine and butorphanol at much lower doses, was considered a suitable alternative to ketamine for short surgical procedures under anaesthesia.[12] Alfaxalone in cats also resulted in better recovery quality than the ketamine combinations. This further supported the plan to evaluate alternatives to azaperone as it is known that ketamine with azaperone leads to a high incidence of stressful stormy and prolonged recoveries in piglets.[5,7,25]

In addition to the triple drug combination of alfaxalone, dexmedetomidine and an opioid, our piglets also received the NSAID meloxicam 20 minutes prior to induction of anaesthesia. Meloxicam has been shown to provide good post operative analgesia for piglet castration when tested as a sole agent.[30] The combined use of meloxicam with intra testicular lidocaine resulted in reduced serum cortisol concentrations following castration[4] with the same dose as in our study. However, acute responses to surgery were not reported.

We chose 10 minutes after the IM drug administration as the time to administer intra testicular lidocaine if anaesthesia was considered inadequate in order to carry out the surgery. A study evaluating alfaxalone 5 mg/kg with 0,5 mg/kg diazepam in 2 month old pigs reported onset of lateral recumbency within 140–260 seconds of IM drug administration. However peak effect following IM injection in either piglets or pigs does not appear to be reported in the literature. In dogs, alphaxalone plasma concentration peaks within the first 10 minutes after IM injection and declines rapidly thereafter.[6] The 10 minute cut-off was chosen in order not to delay surgery into the period after drug administration when plasma concentration would already have started to decrease. We also chose the 10 minute cut-off to avoid giving an intra testicular injection to a piglet which was starting to regain consciousness. Inevitably, we did not establish whether a longer time period would have led to deeper anaesthesia and better results. However, in the light of the reported pharmacokinetics and onset-offset time in several species, it seems unlikely that anaesthesia would have deepened beyond 10 minutes.

In the present study even locally injected 4 mg/kg lidocaine per testis did not prevent purposeful reaction to surgery in most piglets. Local lidocaine administered to 5 month old pigs resulted in analgesia considered satisfactory for castration.[16] Our piglets were castrated within the first two weeks of life, as this is common standard. Since the lidocaine dose was given according to body weight the volume of intra testicular lidocaine was very small compared with that used in a 5 month old and may not have distributed well around the testis. Less time was allowed after lidocaine injection until castration in our study (1 minute) compared with the older pigs (5 minutes). These features offer a possible explanation for the inadequacy of the lidocaine effect in our piglets. A similar lidocaine dose given to piglets during isoflurane anaesthesia (4 or 8 mg/kg intra testicular) produced a satisfactory effect after 120 seconds, reducing purposeful movements from 67 to 17 %.[10] It appears that we should have allowed longer after the lidocaine administration before commencing surgery.

It remains imperative to find an anaesthetic that can be given as a single IM injection which leads to anaesthesia and sufficient analgesia to castrate piglets within a short time frame, to limit separation time from the mother sow. Every step in the pig industry is considered to be a potential loss of money and separation of piglets from the mother sow is stressful. Anything apparently unnecessary or extra will therefore never gain wide acceptance by those working in the industry. Unfortunately, in this study, in spite of the promise of previous publications, even high doses of alfaxalone and dexmedetomidine and the addition of either butorphanol 0,2 mg/kg or pethidine 0,4 mg/kg failed to produce adequate intraoperative analgesia. Further increases in dose were not considered an option, as recovery duration was close to the two hour maximum proposed and periods of oxygen haemoglobin desaturation increasing. The tested

combinations did not meet the required criteria, therefore the originally intended blinded comparison to the current standard (azaperone - ketamine) was not undertaken.

Conclusions
Escalating intramuscular doses of dexmedetomidine (up to 40 µg/kg) combined with alfaxalone (up to 6 mg/kg) were tested with or without butorphanol or pethidine. No combination provided satisfactory anaesthesia for surgical castration in piglets aged between two and eight days. Satisfactory anaesthesia entailed no movement during surgery, adequate oxygenation, excitation-free induction and recovery and piglets standing within two hours of drug administration.

Anaesthesia for castration of 2–8 day old piglets using dexmedetomidine-alfaxalone with or without butorphanol or pethidine

M. Lentini, P. Taylor Monroe, R. Irvine, D. Corona, R. Bettschart-Wolfensberger

Anesthésie pour la castration de porcelets âgés de 2 à 8 jours à l'aide de dexmédétomidine-alfaxalone avec ou sans butorphanol ou péthidine

L'anesthésie intramusculaire actuellement utilisée pour la castration des porcelets, qui associe l'azapérone et la kétamine, n'est pas satisfaisante en termes d'anesthésie et de récupération. Cette étude visait à évaluer différentes combinaisons de médicaments intramusculaires afin d'obtenir une anesthésie sans mouvement ni vocalisation pendant l'intervention chirurgicale, tout en maintenant une saturation en oxygène de l'hémoglobine (SpO_2) > 90 % et une induction et une récupération sans excitation, les porcelets se tenant debout dans les deux heures suivant l'administration des médicaments.

L'alfaxalone et la dexmédétomidine ont été administrées à 19 porcelets à des doses initiales de 2 mg/kg et 25 µg/kg, respectivement. Si deux porcelets consécutifs bougeaient pendant l'intervention chirurgicale, les doses étaient augmentées selon un schéma posologique prédéterminé, avec des doses maximales de 6 mg/kg d'alfaxalone et 40 µg/kg de dexmédétomidine. En cas de réaction au pincement nasal préopératoire, 4 mg/kg de lidocaïne à 2 % étaient injectés dans le testicule. Malgré l'anesthésie locale ou l'absence de réaction au pincement du nez indiquant une profondeur d'anesthésie suffisante, seul un porcelet n'a pas réagi à la compression du cordon spermatique. Par conséquent, 12 autres porcelets ont reçu au hasard 40, 50 ou 60 µg/kg de dexmédétomidine et 5 mg/kg d'alfaxalone, avec ou sans butorphanol 0,2 mg/kg. Un seul porcelet, après administration de butorphanol et de 40 µg/kg de dexmédétomidine, n'a pas bougé pendant l'intervention chirurgicale. Par conséquent, huit autres porcelets ont reçu 40 µg/kg de dexmédétomidine, 5 mg/kg d'alfaxalone et 4 mg/kg de péthidine. Cependant, tous les porcelets ont réagi à l'intervention chirurgicale et la SpO_2 était inférieure à 90 %. Aucun autre test n'a été effectué.

En conclusion, aucune des combinaisons testées d'alfaxalone et de dexmédétomidine, avec ou sans opioïde, n'a permis d'obtenir une anesthésie satisfaisante pour la castration chirurgicale de porcelets âgés de deux à huit jours.

Mots clés: verrat, porc, castration, analgésie, hypnose

Anestesia per la castrazione di suinetti di 2–8 gio rni di età mediante dexmedetomidina-alfaxalone con o senza butorfanolo o petidina

L'anestesia intramuscolare attualmente utilizzata per la castrazione dei suinetti, che coinvolge azaperone e ketamina, risulta insoddisfacente sia per l'anestesia che per il recupero. Questo studio aveva l'obiettivo di valutare diverse combinazioni di farmaci somministrati per via intramuscolare per ottenere un'anestesia che evitasse movimenti o vocalizzazioni durante l'intervento, mantenendo la saturazione dell'ossigeno emoglobinico (SpO_2) >90 %, con un'induzione e un recupero privi di eccitazione, e con suinetti in piedi entro due ore dalla somministrazione dei farmaci.

Alfaxalone e dexmedetomidina sono stati somministrati a 19 suinetti con dosi iniziali di 2 mg/kg e 25 µg/kg, rispettivamente. Se due suinetti consecutivi si muovevano durante l'intervento, le dosi venivano aumentate secondo un protocollo prestabilito, fino a un massimo di 6 mg/kg di alfaxalone e 40 µg/kg di dexmedetomidina. In caso di reazione al pizzicotto nasale prechirurgico, venivano iniettati 4 mg/kg di lidocaina al 2 % a livello intratesticolare. Nonostante l'anestesia locale o l'assenza di reazione al pizzicotto suggerisse una profondità anestetica adeguata, solo un suinetto non ha reagito alla trazione del funicolo spermatico. Di conseguenza, altri 12 suinetti hanno ricevuto, in modo casuale, 40, 50 o 60 µg/kg di dexmedetomidina e 5 mg/kg di alfaxalone, con o senza butorfanolo a 0,2 mg/kg. Solo un suinetto, trattato con butorfanolo e 40 µg/kg di dexmedetomidina, non si è mosso durante l'intervento. Pertanto, altri otto suinetti hanno ricevuto 40 µg/kg di dexmedetomidina, 5 mg/kg di alfaxalone e 4 mg/kg di petidina. Tuttavia, tutti i suinetti hanno reagito all'intervento e la SpO_2 era inferiore al 90 %. Non sono stati effettuati ulteriori test.

Per concludere possiamo affermare che nessuna delle combinazioni testate di alfaxalone e dexmedetomidina, con o senza oppioidi, ha fornito un'anestesia soddisfacente per la castrazione chirurgica di suinetti di età compresa tra due e otto giorni.

Parole chiave: verro, suino, castrazione, analgesia, ipnosi

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