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Vocal responses of piglets to castration: identifying procedural sources of pain

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Abstract

The aims of this study were to identify which aspects of castration are painful to piglets, and to determine if less painful methods are available. Previous work has shown that piglets produce more high frequency calls (>1 kHz) when castrated than when handled identically but not castrated, or when castrated using a local anesthetic. In Experiment 1, we used 90 piglets to assess the vocal responses to different components of the castration procedure: restraint, washing the ano-genital region, scrotal incision, and pulling/severing of the spermatic cords. Compared to sham-operated animals (which were restrained and washed but not castrated) incision of the scrotum produced much more high-frequency calling than restraint alone at the same stage of the procedure. Pulling and severing the spermatic cords evoked the greatest amount of calling, significantly more than the incision, regardless of the order in which the incision and pull/sever were performed ($P<0.001$). In Experiment 2 (49 piglets), we found no difference in calling between two methods routinely used to sever the spermatic cord: cutting the cord with a scalpel versus tearing the cord by pulling on the testicle. These findings suggest that the pulling and severing of the spermatic cords are the most painful components of castration, yet altering the method of severing resulted in no change in call rate. Rather than focusing on pain control, welfare problems associated with castration may be better reduced by using non-surgical approaches, or by eliminating the need for castration in the first place. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

In many countries male piglets are routinely castrated to prevent boar-tainted meat and the difficulty of managing and handling intact boars. Castration is typically performed without anesthesia or analgesia, and includes several events likely to be painful: scrotal incision, extraction of the testes, and severing the spermatic cords. Assessing pain in non-human animals, as in pre- or non-verbal humans, is a challenging task (Morton and Griffiths, 1985; Levin, 1994). Lacking the ability to report verbally on the relative severity of painful procedures, animal subjects depend upon caretakers or observers to detect the often-subtle differences in behaviour or condition that may signal pain. Signs of pain in farm animals may include aggression, fear and escape responses, self-mutilation, sweating, recumbency, or vocalizations (Morton and Griffiths, 1985; Duncan and Molony, 1986; National Academy of Sciences, 1992). Vocal responses to painful stimuli are often species-typical (e.g. Morton and Griffiths, 1985), and have been used to assess the effect of a variety of procedures including tail docking of puppies (Noonan et al., 1996), ear-notching of piglets (Noonan et al., 1994), and branding of calves (Watts and Stookey, 1999). Vocalizations have also been used in human infants to assess heel-lancing, injections (Grunau et al., 1990; Craig et al., 1993), and circumcision (e.g. Porter et al., 1986).

Researchers have also explored the vocal response of piglets to castration without anesthetics or analgesics (Wemelsfelder and Van Putten, 1985; White et al., 1995; Weary et al., 1998). Although piglets typically vocalize a great deal when simply restrained, they vocalize much more when castrated than if identically handled but not castrated (Weary et al., 1998) or than if castrated with local analgesic (White et al., 1995). More specifically, castrated piglets appear to produce calls of greater range (Wemelsfelder and Van Putten, 1985) and higher frequency (White et al., 1995; Weary et al., 1998) than controls.

Variation in piglet vocalizations may reflect not only gross quantitative differences in pain (as in castrate-sham comparisons), but also more subtle effects, such as the intensity or nature of the pain experienced. Routine castrations are typically done rapidly and in fixed order, which blurs any distinction of vocal response to a single procedural element and confounds the effects of different events with time. As earlier work assessing piglets' vocal responses to castration suggested that the extraction of the testes and severing of the spermatic cords are the most aversive components of the castration process (White et al., 1995; Weary et al., 1998), the aim of our first experiment was to perform a more definitive test by: (1) varying the order of the individual events relative to time, and (2) introducing brief delays between the events.

Based on the findings of Experiment 1, and in the interests of trying to reduce pain due to castration, the objective of Experiment 2 was to compare different methods of severing the spermatic cords. As with many traditional agricultural practices, there is considerable variation in how castrations are performed. For example, the spermatic cord is sometimes cut cleanly using a scalpel, but the scalpel can also be used to shave down the cord. The cord can also be torn by pulling on the testicle, or even cut with the teeth (Harvey, 1847, p.106). These latter methods result in a more ragged cut, long believed to reduce bleeding compared to the clean cut of a scalpel blade. If severing the cord is painful, than it is important to identify the least painful methods of performing this task. In Experiment 2, we

compared the vocal responses of piglets to two methods commonly used on Canadian farms: cutting with scalpel and tearing by pulling on the testicle.

2. Experiment 1

2.1. Materials and methods

Sixteen litters, each with three or more healthy males, provided 30 sets of three littermates which were assigned (randomly and without replacement) to the three treatments in Table 1. In six cases, a female was used as the sham animal after preliminary analyses showed no difference between male and female shams for any call features.

Castration was considered as constituting four components: (1) initial restraint, (2) washing the ano-genital area, (3) incising the scrotum (during which the testicle was externalized), and (4) pulling the testicle and severing the spermatic cords. Because the incision and pull/sever events are performed twice (once for each testicle), the order of the components could be varied to form Treatments 1 and 2 (Table 1), thus allowing a comparison of the incision and pull/sever events at different stages in the procedure. All events were performed at 15 s intervals, in order to identify vocal responses to individual events without carrying over from preceding events. Observations made during previous castration studies suggest that a piglet's immediate vocal response diminishes after only a few seconds.

Males were castrated between 7 and 10 days of age. All piglets in a litter were removed from the sow and placed in a box in visual and acoustic isolation from the procedure room. Focal piglets were carried individually and gently to the procedure room, weighed, treated, and then returned to their littermates. Once all required piglets were treated, the litter was returned to the sow.

For castration, piglets were restrained for 90 s in dorso-caudal recumbency on a narrow wooden bench with their backs supported against the handler's torso. The piglets' hind legs were held forward over their abdomens to expose the ano-genital region to the castrator. The 90 s were divided into six 15 s intervals, signalled on the audio recording by an audible tap on the microphone.

Piglet vocalizations were recorded via a microphone (Beyerdynamic MCE86N(C)S) suspended 0.5 m above the head of the piglet onto a Sony DAT Walkman TCD-D7 tape

Table 1
Timing and order of castration events in Experiment 1

Stage	Time (h)	Treatment 1	Treatment 2	Sham
1	0.00	Restrain	Restrain	Restrain
2	0.15	Wash	Wash	Wash
3	0.30	Incision	Incision	–
4	0.45	Pull/cut cord	Incision	–
5	1.00	Incision	Pull/cut cord	–
6	1.15	Pull/cut cord	Pull/cut cord	–

recorder. During the first 15 s period, the piglet was simply restrained on the bench. At the start of the second 15 s period, the ano-genital area was gently washed with disinfectant-soaked gauze (Cida-Rinse, Huntingdon Laboratories, Huntingdon, IN) for approximately 5 s. At the beginning of the next interval, the first testicle was palpated caudally and the scrotum incised with a single cut with a sharp scalpel. Due to the pressure of the castrator's finger on the scrotum, the testicle was externalized in the process of making the incision. The testicle was lifted approximately 3 cm away from the animal's body to allow the spermatic cords to be easily severed. The balance of the procedure was carried out according to the assigned treatment, with all events immediately following an acoustic marker. Finally, aerosol disinfectant was sprayed into and onto the incision (Red-Kote, H.W. Naylor Co. Ltd., Morris, NY). Sham-castrated piglets were restrained and washed identically to their castrated littermates, but then simply restrained until the end of the 75 s procedure. Given that the difference in vocal response of sham versus actually-castrated piglets has already been established (Weary et al., 1998), this sham treatment was intended to control for possible temporal effects of restraint.

2.1.1. Animal care

The ultimate aim of our experiments on piglet castration was to identify the least painful methods of performing this procedure. All animals castrated for this study would have been castrated as part of normal farm practice, regardless of this experiment. The brief delays introduced between castration events did have the side effect of slightly prolonging the castration procedure. All animals were cared for and treated in accordance with the local animal care policy and Canadian Council on Animal Care requirements.

2.1.2. Spectral and statistical analyses

Spectral analysis of the recorded piglet vocalizations follows the methods described in Weary et al. (1998). The first 5 s of each stage were digitized (16-bit, 20 kHz sampling rate, input through a Frequency Devices 902 lowpass filter set at 8000 Hz with 20 dB gain) using a personal computer and Signal software (Engineering Design, 1991). This 5 s interval was chosen to focus on the animals' immediate response to the individual events. The time waveform of each sequence was subjected to a smoothing routine (three times at 20 ms and then three more times at 50 ms) to reduce the effect of very short energy peaks and troughs. The program identified individual calls when the energy rose to at least four times the background level for more than 50 ms. Call duration (ms) was calculated by the program based on the time waveform of each call. Peak frequency (Hz) and amplitude (dB) were calculated by Signal using the power spectrum. As in previous castration work in our laboratory (Weary et al., 1998), the distribution of call frequency was bimodal, with the trough at approximately 1000 Hz. Hence, calls were categorized as either low (<1000 Hz) or high (>1000 Hz), and mean call frequencies were calculated and tested separately for the two groups. Call rates for these two call classes, as well as the total call rate, were calculated on a per-second basis.

For statistical analysis, a between-piglet comparison was made of the overall effects of castration (sham or castrated) and treatment (1 or 2; Table 1). The analysis of variance model included terms for litter (15 d.f.), castration (sham versus castrated; 1 d.f.), and

treatment within castration (i.e. Treatment 1 or 2; 1 d.f.) tested against a residual error term (71 d.f.).

To better control for between-subject variation, a within-subject comparison was carried out using data only from the castrated piglets and Stages 4–5. The statistical model for the within-piglet test of event included terms for litter (15 d.f.), pig within litter (43 d.f.) and event (1 d.f.), tested against a residual error term with 58 d.f. One piglet was excluded from the analysis because of technical problems with the recording.

2.2. Results and discussion

There were no differences in piglets' vocal responses to restraint and washing among the three treatment groups during Stages 1 and 2 when all piglets received identical handling (Fig. 1A and B).

During all of Stages 3–6, castrated piglets produced significantly more high frequency calls than sham piglets (Fig. 1A). The rate of low frequency calls did not differ consistently between sham and castrated animals, but was significantly higher for the castrates in two of four of the castration stages ($P<0.05$). As a result mostly of the increase in high call rate, the total call rate was significantly higher for castrates during the four castration stages (3–6;
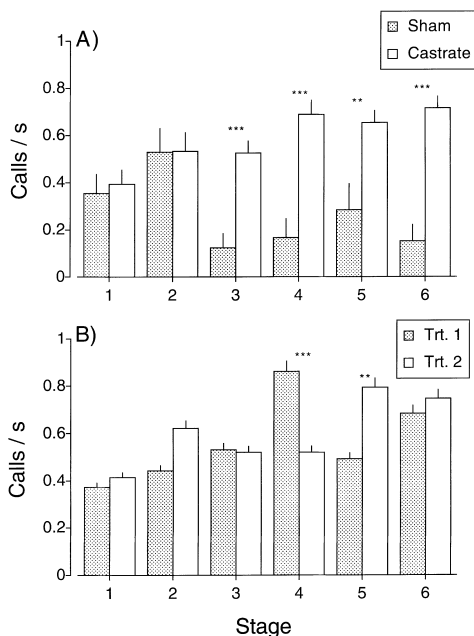

Fig. 1. The mean (+S.E.M.) rate of high frequency calls (>1000 Hz) in Experiment 1. Part A compares sham piglets with piglets on both castration treatments combined (1 and 2). Part B compares the two castration treatment groups (1 and 2) at various stages. In Stage 4, Treatment 1 underwent the pulling and cutting of the cords while Treatment 2 received the second incision. These events were reversed in Stage 5. Asterisks indicate significant differences between points at a given stage (** — $P<0.01$; *** — $P<0.001$).

$P<0.001$). Interestingly, the sham/castrate difference was due primarily to a decline in calling by the sham piglets after Stage 2 (Fig. 1A). During Stages 3–6 (after initial restraint and washing) the call rate of sham piglets remained fairly constant. Thus, once a sham piglet had settled into position and was not being touched, it gave few high frequency calls for the balance of the 90 s procedure.

There was no difference between Treatments 1 and 2 during Stages 3 and 6, where the two groups experienced identical events (incision and pull/sever, respectively). During Stages 4 and 5, however, pigs of both treatments produced significantly more high frequency calls during the pull/sever event than during the scrotal incisions ($P<0.001$; Fig. 1B). Low call rate did not vary with castration event.

Consistent with the above results, the within-subject comparison of incise versus pull/sever events during Stages 4 and 5 revealed a significantly greater vocal response to pull/sever than to incise for both high call rate and total call rate ($P<0.001$). For example, the mean (+S.E.M.) rate of high calls during the incision was 0.49 (+0.04) versus 0.81 (+0.04) during the pull/sever.

In summary, castrated piglets produced more high frequency calls than identically restrained but non-castrated littermates during Stages 3–6 of castration. These findings are consistent with prior work in our own laboratory (Weary et al., 1998) and elsewhere (Wemelsfelder and Van Putten, 1985; White et al., 1995), all of which have reported that castrated piglets produce higher frequency calls than their non-castrated, sham-castrated, or locally-anesthetized littermates. The results also indicate that there is greater pain associated with pulling the testicle and severing the spermatic cords than with the scrotal incision.

3. Experiment 2

3.1. Materials and methods

Forty-nine male piglets from 12 litters aged 7–13 days were randomly allocated to one of two groups. Each piglet provided a within-subject test of two castration methods, the order of which was varied to produce the two sequences shown in Table 2.

One castration method involved severing the spermatic cords with a sharp scalpel, as done in Experiment 1. In the second method, which is recommended and commonly used

Table 2
Castration treatments and timing for Experiment 2

Stage	Time (h)	Treatment 1	Treatment 2
1	0.00	Restrain	Restrain
2	0.15	Incision	Incision
3	0.30	Cut cord	Trim and pull cord
4	0.45	Incision	Incision
5	1.00	Trim and pull cord	Cut cord
6	1.15	Spray	Spray

in Canada, the testicle was externalized, the tunica vaginalis trimmed away from the testicle, and the testicle removed by pulling. Trimming the tunica vaginalis prevents traction up the inguinal canal, and may, therefore, help reduce pain.

Litters were removed from the sow and brought to the procedure room as in Experiment 1. The order of treatment of individual piglets was randomized. Each piglet was caught, weighed, and his ano-genital region washed. The piglet was then placed on the castration bench as in Experiment 1, at which point timing began. After the first 15 s restraint interval, the first scrotal incision was performed, and the procedure continued as outlined in Table 2. As in Experiment 1, intervals were marked acoustically by tapping the microphone at 15 s intervals.

The vocal data from the first 5 s of each interval were analysed as in Experiment 1. A between-subject test of castration method used a general liner model incorporating a litter term (11 d.f.) and testing treatment (1 d.f.) against the residual error term (36 d.f.) for each stage of the castration process. A within-subject test of castration method used a general linear model including a litter term (11 d.f.) and testing pig-within-litter (37 d.f.) and castration method (1 d.f.) against the residual error term (45 d.f.). Other aspects of the methods were identical to that described for Experiment 1.

3.2. Results and discussion

Between-subject testing revealed no difference between the two treatment groups during Stages 1–3, and 5 in which piglets experienced identical events. During Stages 4 and 6, when the treatment groups experienced different methods of severing the spermatic cords (trim/pull versus cut), there was also no difference. During Stage 4, for example, piglets having their spermatic cords cut produced 0.74 (+0.09) high-frequency calls/s while those whose cords were torn by pulling produced 0.70 (+0.09) calls/s. Within-piglet testing of method confirmed these initial findings of no difference. Thus, it appears that piglets do not respond differently to these two methods of severing the spermatic cords during castration.

Our informal observations during this study support the assertion that severing the spermatic cords by pulling resulted in less bleeding. However, it is possible that pulling the testes resulted in a break in the spermatic cords more proximal than the cut performed with the scalpel, and so any bleeding may have simply been less visible.

4. General discussion

In Experiment 1, piglets produced significantly more high-frequency calls during stages when the testes were being pulled and the cords cut than during scrotal incision, regardless of the order of these two events. The results suggest that piglets find pain associated with pulling the testes and the severing of the spermatic cords greater (or qualitatively different) from the other components of the procedure, as had been suggested in earlier studies (White et al., 1995; Weary et al., 1998). It has yet to be determined if the pulling or severing is more painful, but this question will be difficult to address given that castration would seem to require applying traction to the testes.

Human experience suggests that cutaneous pain (like that associated with the scrotal incision) is different from visceral pain (likely associated with testicle extraction and the severing of the spermatic cords) (Kitchell, 1987). Cutaneous pain is typically sharp, stinging, and highly localized, whereas visceral pain is dull, diffuse, and poorly localized (Schmidt, 1986, pp. 118–119). Further, visceral pain may result from non-damaging tissue manipulation, such as distension or traction, and may trigger autonomic responses (FELASA, 1994; Meyer et al., 1994, p. 32). In addition, the testes are well innervated, making them among the few viscera which produce sharp, well-localized pain (FELASA, 1994).

In Experiment 2, we considered two methods of severing the spermatic cords in the hope of finding a way to reduce the pain experienced by the animals during castration. We found no difference in vocal response to severing the cord by scalpel cut versus removing the testicle by simply pulling. It is possible that the two castration methods are actually equivalent in terms of the pain they inflict upon the subjects. Alternatively, there may be a ceiling to the piglet's ability to respond vocally to pain, such that the two events both evoked a maximum response. Also, the actual severing of the spermatic cords may not be the most painful component of the pull/sever event. Traction upon the testes in the process of externalization is likely felt along the length of the spermatic cords and up into the inguinal canal. This traction may not cause actual tissue damage (as in severing the cords), but it is possible that this pain may overshadow that due to the very quick cutting or tearing of the spermatic cords during castration.

There has been little other work exploring differential vocal response to different types of pain, even in humans. The calls of unanesthetized human infants during circumcision have been shown to reflect the various surgical events; more invasive events produced more cries of (among other things) shorter duration and higher peak frequency (e.g. Porter et al., 1986). However, human circumcision studies typically do not include sham or control subjects. It is, therefore, difficult to assess whether the same call features that distinguish events of differing severity also indicate the presence of pain in the first place or whether different call features may indicate quantitative and qualitative aspects.

4.1. Implications

Whereas there is a body of ongoing research investigating the pain associated with different methods of castrating lambs and calves (e.g. Molony et al., 1995; Lester et al., 1996), there has little similar work in pigs. Because the testes of the pig are less fully externalized than those of cattle and sheep, rubber ring and Burdizzo methods of castration are not feasible, and surgical castration is really the only practical method currently available.

Results from this and earlier studies (White et al., 1995; Weary et al., 1998), have not succeeded in identifying practical alternative procedures that allow for less painful castration. However, they may help to clarify what options merit further study. Certainly the findings of the current study indicate that the pulling of the testes and severing of the spermatic cord are more painful than the scrotal incision. Thus, application of a topical analgesic to the scrotal area is unlikely to be a satisfactory solution. Local anesthetics infused into the scrotum do help reduce the response to castration (White et al., 1995), but

add a step to the process potentially increasing the stress of handling and restraint. General anesthesia can involve risks and may disrupt normal nursing and heat-seeking behaviours post-operatively, resulting in poor piglet recovery (McGlone and Hellman, 1988). One alternative might be a brief gas-induced general anesthetic, but more work is required to develop safe, convenient, and effective ways to administer analgesics or anesthetics for this application (e.g. Thurmon et al., 1991).

Given the practical difficulties in reducing the pain associated with surgical castration, a more promising solution may be to pursue non-surgical alternatives. For example, male pigs can be 'immunocastrated' by means of immunological suppression of the sex hormones that cause boar taint (Bonneau and Enright, 1995; Oonk et al., 1998). A final approach is to simply rear males intact. Selecting boars for slightly later sexual maturity, or shifting marketing preferences towards slightly lighter (younger) carcasses, would help eliminate boar taint and inter-male aggression, while allowing producers to enjoy the production benefits associated with rearing intact males.

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