Survey of the effectiveness of stunning procedures used in Spanish pig abattoirs

A. VELARDE, M. GISPERT, L. FAUCITANO, X. MANTECA, A. DIESTRE

Two pig abattoirs (A and B) equipped with an automated head-only and head-to-chest electrical stunning system, and two (C and D) equipped with a manual carbon dioxide stunning system, were evaluated to compare the effectiveness of stunning in a total of 10,454 pigs slaughtered under commercial conditions. In the abattoirs with the electrical stunning system, the percentage of animals that responded to a nose prick was significantly lower (P<0.05) in abattoir B, where a higher current intensity was used (P<0.05), than in abattoir A. No righting reflex was observed in the electrically stunned pigs. In the abattoirs with the carbon dioxide stunning system, the percentage of animals that responded to a nose prick and showed a righting reflex was significantly lower (P<0.05) in abattoir C, where the duration of the carbon dioxide cycle was longer and the interval between discharge from the system to striking was shorter (P<0.05), than in D. Comparing the electrical and carbon dioxide stunning systems, the pigs stunned with carbon dioxide were significantly more responsive to a nose prick (P<0.05) and 25 per cent of them showed a righting reflex. Under the conditions of the study the fully automated head-only stunning with additional chest electrodes appeared to be more effective and less susceptible to incorrect handling than the manual carbon dioxide stunning system.

ELECTRICAL stunning is the most widely used method for stunning pigs; it consists of passing electricity through the brain to produce insensibility instantaneously. The pigs are stunned by eliciting a tonic/clonic epileptic seizure, effectively preventing any pain stimulus from being processed in the central nervous system. As a result of its adverse effects on meat quality, and because of the potential animal welfare problems associated with the possibility of some pigs recovering sensibility, in some Spanish abattoirs the traditional head-only electrical stunning system has been replaced by head-to-chest electrical stunning, combined with the chest-belt restrainer (MIDAS system). The application of the cardiac arrest cycle has a major animal welfare advantage in that the pigs begin to die at the point of stun, striking becomes merely a method of removing blood from the carcass (Wotton and Gregory 1986), and if the pigs are not bled out they will not regain consciousness (Lamböoj and others 1996).

Following the trend in Scandinavian countries, the use of carbon dioxide for stunning pigs has recently increased in popularity in Spain. The animals are immersed in a chamber containing a high concentration (minimum of 70 per cent) of the gas. However, its acceptability on welfare grounds has been questioned by Raj and Gregory (1995). The arguments that carbon dioxide stunning is an inhumane procedure are based primarily on the prolonged, unpleasant induction period. Gregory and others (1987) examined the effectiveness of one type of stunner (Compact Unit; Butina) and suggested that the pigs did not become insensible immediately and that narcosis began 30 to 39 seconds after the start of the immersion procedure. In addition, when the animals are exposed to the gas they become severely breathless while they are still conscious, and they may show violent motor activity (Raj and Gregory 1995). However, from a study of the changes in the electroencephalogram patterns of pigs, Forslid (1987) concluded that pigs became insensible well before the onset of the motor activity.

The aim of this survey was to evaluate and compare, under practical conditions, the effectiveness of the head-to-chest electrical stunning system and carbon dioxide stunning on the loss of sensibility of pigs.

MATERIALS AND METHODS

Four commercial pig abattoirs in Spain, located in different areas, with differences in access, lairage conditions and methods of handling in general, were assessed in terms of the post-stunning behaviour of pigs stunned either electrically or with carbon dioxide. They were chosen as having the most up-to-date stunning methods for pigs.

Two of the abattoirs (A and B) were equipped with the MIDAS stunning system (Stork RMS) in which the animals are supported on a moving conveyor belt. The animals had electrodes applied automatically for both the head-only stunning and the head-to-chest cardiac arrest (NARCO constant voltage). The electrodes were designed to pierce the skin to reduce the electrode-skin impedance and hence maintain optimum current levels. The head-only stunning electrodes were applied between the eyes and ears on either side of the head, and delivered the current at a frequency of 800 Hz for 2.3 to
2-4 seconds. After 0-7 to 1 second of the head electrode application, an additional electrode was applied caudal to the left elbow of the pig so that a current at a frequency of 50 Hz was delivered for 1-7 to 1-9 seconds between the head and chest electrodes to induce a cardiac arrest. At abattoir A, the effective voltage at the head stunning electrodes was 220 V and the voltage at the cardiac electrode was 110 V. At abattoir B, the voltage at the head stunning electrode was 270 V and the voltage at the cardiac arrest electrode was 175 V. Each stunning system was equipped with a system to measure the current and the time for which it was applied, and these data were recorded automatically by a computer. At both abattoirs, after stunning, the pigs fell on to a moving table and were exsanguinated in a lying position between 5 and 10 seconds after the stun.

The other two abattoirs (C and D) were equipped with a Compact Carbon Dioxide Stunning Unit (Butina ApS). The unit was a six chair paternoster-type conveyor which loaded two pigs at a time and placed them at the base of a well that contained carbon dioxide and air. The mean atmospheric concentration of carbon dioxide was 83 per cent at the bottom of the well. After stunning, the animals were returned to a position alongside the loading point and hung vertically on the bleed rail, where they were exsanguinated. The mean (se) interval between the pigs being discharged from the system and sticking was 43 (5) seconds at abattoir C and 58 (10) seconds at abattoir D.

The studies at each abattoir were made over three days and 2977 crossbred slaughter pigs were slaughtered at abattoir A, 2930 at abattoir B, 1684 at abattoir C, and 2863 at abattoir D, a total of 10,454 which was considered as a representative sample of the national pig population. Plant C operated at a low line speed (260 pigs per hour), plants A and D operated at a medium line speed (400 and 380 pigs per hour, respectively) and plant B operated at the highest line speed (550 pigs per hour).

**Evaluation of loss of sensibility**

At each of the four abattoirs, the pigs' response to pain induced by a nose prick with a hypodermic needle was recorded as an indication of effective stunning and insensibility at 30 to 35 seconds after stunning. In addition, the presence or absence of the righting reflex was recorded continuously after exsanguination until the death of the animal, either on the moving table in the case of the electrically stunned pigs, or while they were hoisted (arched back reflex) on to the bleeding rail in the case of the pigs stunned with carbon dioxide. The presence of this reflex would suggest that the animals were beginning to recover consciousness while bleeding.

In the abattoirs equipped with the electrical stunning system, information on the position of the tongs was recorded. It was classified as incorrect placement of the head electrode when the tong was applied cranial to the eyes, that is on the snout, in accordance with the recommendations of Anil and McKinstry (1998). It was classified as incorrect placement of the chest electrode when the electrode was applied cranial to the correct position, that is cranial to the elbow. The effectiveness of stunning was also determined by monitoring the presence of tonic/clonic activity. Pigs were considered to have been incorrectly head-only stunned when they did not show tonic/clonic phases. The clonic phase was differentiated from voluntary movements occurring in pigs that regained consciousness on the basis that the clonic phase consisted of repeat kicking movements, particularly of the hindlegs, whereas voluntary movements were intermittent and involved the whole body. The animals were evaluated by three observers while they were lying on the shackling table and after they had been stuck.

In the abattoirs using the carbon dioxide system, other physical reflexes of the pigs, such as loss of posture (recumency) and relaxed extremities were tested before they were conveyed from the shackling table to the rail and before sticking. The presence of these reflexes would suggest that the pigs had been correctly stunned.

**Statistical analysis**

The data were analysed statistically by analysis of variance, and the percentages of pigs either showing or not showing signs of recovery were analysed by using relative risk (RR) analysis with the SPSS for Windows version 7.5.

**RESULTS**

**Electrical stunning**

The intensity of the electrical currents used to stun the animals at abattoirs A and B are shown in Fig 1. The mean (se) values were as follows: the head-only stunning current was 1-9 (0-10) A at abattoir A and 2-5 (0-20) A at abattoir B, and the head-to-chest cardiac arrest current was 1-2 (0-04) A at abattoir A and 1-6 (0-08) A at abattoir B. As shown in Table 1, the intensities of both the head-only and the head-to-chest cardiac arrest currents were significantly different (P<0.05) at the two abattoirs. The frequency of incorrect placement of the head electrodes was 13-27 per cent at abattoir A and 14-12 per cent at abattoir B. However, the percentages of pigs showing an absence of the tonic/clonic phase as an indicator of incorrect stunning were 1-38 per cent at abattoir A and 1-10 per cent at abattoir B and much lower than the percentages with incorrect placement of the head electrodes. The frequency of incorrect placement of the chest electrodes was 9-07 per cent at abattoir A and 9-80 per cent at abattoir B, a significant difference (P<0-05), but in both cases the percentages of animals showing sensibility to pain (0-9 per cent at abattoir A and 0-3 per cent at abattoir B) were much lower, and the percentage was 3-7 times greater at abattoir A than at abattoir B (P<0-05).
No righting reflex was observed in any of the electrically stunned pigs. The mean carcass weight was 77.8 (9.4) kg at abattoir A and 78.3 (9.7) kg at abattoir B.

**Carbon dioxide stunning**

The mean time of exposure to carbon dioxide was significantly (P<0.05) longer at abattoir C than at abattoir D (103 (69-92) v 92 (41-111) seconds) (Table 1). All the variables that indicated the presence of consciousness were significantly greater (P<0.05) at abattoir D than at abattoir C, with the exception of recovery from recumbency for which there was no significant difference. The presence of the arched back righting reflex observed after pigs were exsanguinated was considered to be associated with pigs which were either sensible or regaining sensibility. The righting reflex was observed in 12.8 per cent and 33.3 per cent of the pigs at abattoirs C and D, respectively. At abattoir C, where the mean carbon dioxide cycle time was significantly longer (P<0.05) than at abattoir D, there was no significant difference between the mean exposure times of the pigs with and without the righting reflex (104 (68-102) v 102 (23-26) seconds). However, at abattoir D the mean carbon dioxide cycle time of the pigs that had the righting reflex was significantly shorter (P<0.05) than that of the pigs that did not (91 (63-96) v 93 (56-67) seconds). In both abattoirs, 90 per cent of the animals which were subjected to a carbon dioxide cycle longer than 130 seconds did not show either a response to pain or a righting reflex. The mean carcass weight was 76.2 (9.2) kg at abattoir C and 76.2 (9.7) kg at abattoir D.

Comparing the pooled data from the abattoirs using electrical stunning with the pooled data from the abattoirs using carbon dioxide, the percentages of pigs showing sensibility to pain (P=0.07 per cent v 28.6 per cent) and the righting reflex (0 per cent v 25 per cent) were significantly lower in the electrically stunned animals (P<0.05) than in those stunned with carbon dioxide.

**DISCUSSION**

Grandin (1997) considered that the maximum frequency of incorrectly placed electrodes could be considered as acceptable from an animal welfare point of view should be less than 2 per cent. In the present study the frequency was much higher in both abattoirs A and B. The difference could be related to some extent to the more stringent criteria being used to measure incorrect placement. Nevertheless, the fact that far fewer electrically stunned animals showed an absence of the tonic/clonic phase and recovered from insensibility before death than had the electrodes placed incorrectly suggests that the intensity of the stun current was too high. In fact, the stun current used by both abattoirs exceeded that recommended by the European Union (1/25 A) to induce insensibility in pigs (Council Directive 91/199/EEC). The use of a high intensity stunning current therefore allows for a greater margin of error in the placement of the electrodes and is more desirable in terms of animal welfare (Anil and McKinstry 1998).

At abattoir A 0-9 per cent of the pigs responded positively to a nose prick, and at abattoir B 0-3 per cent did so, although the electrically stunned pigs were bled out between 5 and 10 seconds after stunning. This short period of insensibility after an incorrectly placed head-to-chest electrical stunning could be explained by the effect of the delivery of a high frequency current (800 Hz) during the head-only application (Anil and McKinstry 1992). In fact, even though high frequency stunning generally produces similar physical responses to stunning with 50 Hz and reduces the involuntary motor activity, it reduces the duration of insensibility. Anil and McKinstry (1992) recommended a stun to sticking interval shorter than 6 seconds to ensure a humane death when the cardiac arrest fails. However, this interval would be impossible to apply to all animals in commercial practice.

The absence of a righting reflex in the electrically stunned pigs after exsanguination may be due to two reasons. First, the head-to-chest application results in cardiac arrest and prevents the recovery of the animals, even when the exsanguination process is delayed. This process is recommended for improving the animals’ welfare and is in agreement with the Council Directive 91/199/EEC. Secondly, if the cardiac arrest is not elicited, the short stun-stick interval prevents the animal from recovering completely.

The differences between abattoirs C and D in terms of the proportions of pigs showing responses to pain and the righting reflex suggest that the effectiveness and duration of the insensibility depends on the duration of the carbon dioxide cycle. However, 10 per cent of the animals subjected to stunning cycles longer than 130 seconds still showed the righting reflex, possibly owing to a delay in sticking. In agreement with Holst (1997), the present results suggest that the minimum carbon dioxide cycle time and the maximum interval between the exit of the pigs from the cradle and sticking should be longer than 130 seconds and shorter than 30 seconds, respectively. This would mean that the maximum line speed of an abattoir with a six chair paternoster-type conveyor stunning system would be 280 pigs per hour, a speed which was achieved only by abattoir C. In this abattoir, the 12.8 per cent of pigs showing the righting reflex may be explained by the cycle time being shorter than that recommended, and the potential bottleneck at sticking was avoided by keeping some chairs empty during the cycle. The precise control of the optimal carbon dioxide cycle time and the interval between the cradle and sticking is therefore difficult to achieve under commercial conditions when the system is controlled manually.

The results of this survey reveal that in the four abattoirs the incorrect handling of the stunning systems led to some animals not being properly stunned, although both systems were designed to be 100 per cent effective. In the abattoirs using the electrical stunning system, any increase in the line speed is likely to increase the frequency with which the electrodes are placed incorrectly. This problem can be partly solved by an increase in current intensity, but it is not enough to ensure the complete insensibility of all the animals slaughtered.

In the abattoirs equipped with the carbon dioxide system, the speed of the cradle cycle needed to be adjusted to that of the bleeding rail, in order to ensure a constant exposure time and prompt sticking of the animals. In abattoir D, the carbon dioxide system was run too quickly for the speed of the bleeding rail, which constantly caused a bottleneck at the sticking point, with numbers of pigs queuing before sticking.

---

**TABLE 1. Mean (+ standard error) characteristics of the stunning systems and the stunning effectiveness at two abattoirs using electrical stunning and two abattoirs using carbon dioxide stunning**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Electrical stunning</th>
<th>Carbon dioxide stunning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity of the head-only current (A)</td>
<td>1.94 (1.08)</td>
<td>2.54 (0.20)</td>
</tr>
<tr>
<td>Intensity of the head-to-crown current (A)</td>
<td>1.25 (0.04)</td>
<td>1.66 (0.08)</td>
</tr>
<tr>
<td>CO2 cycle time (s)</td>
<td>103 (0.69)</td>
<td>92 (0.41)</td>
</tr>
<tr>
<td>Exit of the cradle-sticking interval (%)</td>
<td>1.38</td>
<td>1.10</td>
</tr>
<tr>
<td>Incorrect electrode placement (%)</td>
<td>12.37</td>
<td>9.07</td>
</tr>
<tr>
<td>Absence of tonic/clonic (%)</td>
<td>0.90</td>
<td>0.30</td>
</tr>
<tr>
<td>Absence of recumbent position (%)</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>Presence of sensibility to pain (%)</td>
<td>0.71a</td>
<td>1.78b</td>
</tr>
<tr>
<td>Righting reflex (%)</td>
<td>0.67a</td>
<td>28.5 (5.7)</td>
</tr>
<tr>
<td>Righting reflex (%)</td>
<td>0.67a</td>
<td>28.5 (5.7)</td>
</tr>
</tbody>
</table>

Means with different superscripts within the abattoirs for each stunning method and between stunning methods are significantly different (P<0.05).
Evidence of Muscovy duck parvovirus in Muscovy ducklings in California

P. R. Woolcock, V. Jestin, H. L. Shivaprasad, F. Zwingelstein, C. Arnauld, M. D. McFarland, J. C. Pedersen, D. A. Senne

Muscovy duck parvovirus (MDPV) has been demonstrated in tissue samples from one- to four-week-old commercially reared Muscovy ducks that were weak, unable to walk and had a high mortality rate. On postmortem examination, the thigh and leg muscles, and the myocardium were found to be pale, and there was a fibrinous exudate on the capsule of the liver, and ascites. The parvovirus was isolated in embryonated Muscovy duck eggs and visualised by negative stain electron microscopy, detected by polymerase chain reaction (PCR) directly from the tissues, and antibodies to it were detected by immunoelectron microscopy, ELISA and immunofluorescence. In addition, the PCR products obtained that represented 1625 bp (74 per cent) of the capsid vp1 gene, including a hypervariable region between Derzsy’s disease virus or goose parvovirus and MDPV, were sequenced and shown to be 100 per cent homologous with the MDPV 89384 reference strain, but only 82-3 per cent homologous with Derzsy’s disease virus.

MUSCOVY duck parvovirus (MDPV) was first isolated from Muscovy ducks in the west of France in the autumn of 1989 (Jestin 1990, 1991, Jestin and others 1991b), when it was considered to be a variant of Derzsy’s disease virus or goose parvovirus (GPV). However, the newly isolated virus was more pathogenic for Muscovy duck species and had some antigenic differences in cross-neutralisation tests, although vaccinating Muscovy ducklings with strains of GPV provided them with a high level of protection against a challenge with MDPV (V. Jestin, unpublished observations).

Later observations indicated that the viruses were not pathogenic for goose species (Fournier 1991), and it was suggested that they should be referred to as MDPV. Further investigations at the viral genome level have clearly indicated that there are differences between MDPV and GPV (Zadori and others 1995, Le Gall–Recule and others 1996).

During October 1997, locomotor problems associated with increased mortality (10 to 50 per cent) and morbidity (30 to 80 per cent) were observed in one- to four-week-old, commercially reared Muscovy ducklings in California (Shivaprasad and Woolcock 1998). The locomotor problems included weakness, lateral recumbency and an inability to walk. Both sexes were affected but females were affected more severely. The stunned birds that recovered did not regain normal weight. This paper reports the recovery of a parvovirus from Muscovy ducklings and specifically identifies the virus as MDPV by molecular characterisation. To the authors’ knowledge, this is the first time that MDPV has been detected in the USA.

MATERIALS AND METHODS

Muscovy ducks and tissues examined

Birds aged between one to four weeks and five to nine weeks were examined.

Tissues and/or blood were collected from male (group A) and female (group B) 16-day-old ducklings, received live in December 1997, and from 28-day-old (group C), 17-day-old (group D) and 10-day-old (group E) ducklings received dead in January 1998. Blood samples were also collected for serology.
Survey of the effectiveness of stunning procedures used in Spanish pig abattoirs

A. Velarde, M. Gispert, L. Faucitano, et al.

Veterinary Record 2000 146: 65-68
doi: 10.1136/vr.146.3.65

Updated information and services can be found at:
http://veterinaryrecord.bmj.com/content/146/3/65

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/