RETURN TO CONSCIOUSNESS IN SLAUGHTER PIGS STUNNED WITH CO_2

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Keywords: animal welfare, carbon dioxide, stunning, regaining consciousness, slaughter, pigs

Introduction

Stunning of animals for slaughter is applied to induce a state of unconsciousness which must remain until death occurs as a result of exsanguination (Council Directive 93/119/EC, 1993). If a stunning procedure gives rise to consciousness among animals during or after sticking it is totally unacceptable from the point of view of animal welfare. From a practical point of view, there is no need to stun animals for longer than necessary. Under practical conditions stunning with CO_2 must be carried out in a way to ensure not only good animal welfare, but also high capacity and a low consumption of CO_2 per pig. CO_2 stunning has the advantage that concentration and exposure time can be altered to give shorter or longer periods of unconsciousness, and time to sticking can be longer than e.g. when using electrical stunning (Anil, 1991).

Objectives

The purpose of this study was to investigate the return to consciousness after CO_2 stunning, to optimise the time from stunning to sticking (stun-stick interval) in slaughter pigs and to develop practical methods for evaluation of the depth of anaesthesia.

Material and methods

This experiment took place in a research set-up at a commercial slaughterhouse. In this arrangement pre-slaughter stress is kept to a minimum e.g. by not using goads, and pigs are stunned in a large box, which is essentially a lift (dimensions 1.4 x 2.4 m), which is lowered into the gas and then raised. The flooring is solid, but the sides and roof are made of lattice work to allow fast diffusion of gas into and out of the box (Barton-Gade et al., 1995). 210 slaughter pigs (live weight approx. 100 kg) were randomly chosen from the lairage at least 45 minutes after unloading. The pigs were anaesthetised one by one using a simulated paternoster process with a gas mixture of CO_2 in atmospheric air. The CO_2 concentration in the first position in the gas mixture was set at ≥70% and in the bottom position at ≥90%. Total time in CO_2 was 132 seconds of which 120 seconds were in ≥70% CO_2. The first position was reached after 8 seconds and the bottom position after 40 seconds. The CO_2-gradient in the pit was controlled with a CO_2-meter (85'-meter, Butina). In the paternoster simulation the box-floor was 1.9 metres from the top edge of the pit at the 1st position and 4.8 metres at the bottom. The CO_2-concentration was measured 0.2 metres above the level of the box floor during stops. The actual concentration of CO_2 was measured to 71 ±2% in the first position in the gas and 90 ±1% in the bottom position. Thus pigs were exposed to ≥70% CO_2 within 6-7 seconds of being immersed into the gas.

After stunning the pigs were tipped out onto a belt conveyer and left undisturbed while regaining consciousness. Each pig was continuously examined for different nervous reflexes to evaluate the rate of regaining consciousness. The following reflexes were noted: corneal reflex, cilia (eyelash) reflex, regular respiration, excitation, nystagmus (horisontal vibrating movements of eyeball), spontaneous blinking of the eye, spontaneous movements and attempts to stand up. Regular respiration was defined as being deep and having regular intervals, i.e. different from superficial and occasional gasps. The time from the end of CO_2 exposure to the appearance of reflexes was registered for each pig. Pigs with no corneal reflex after 150 seconds were assumed to be dead and were shackled and exsanguinated. For practical purposes the resting period for the pigs was limited to 15 minutes before returning to the lairage area. They were then slaughtered after an additional rest period.

Results

No pigs showed any reflexes just after the end of CO_2 exposure. Corneal reflex was the first reflex to occur after 45 seconds, and was used to evaluate recovery from the deepest level of anaesthesia just prior to collapse and death. The ciliar reflex followed shortly after, at 54 seconds. Regular respiration occurred after 71 seconds and was used as the first sign of return to consciousness. Excitation was noted after 78 seconds and nystagmus after 85 seconds. Excitation and nystagmus did not occur in all pigs. 77% of the pigs showed excitation to a greater or lesser extent and only 42% showed nystagmus. Spontaneous blinking of the eye occurred after 98 seconds and was together with nystagmus used to indicate imminent return to consciousness. Spontaneous movements of head or legs were observed after 174 seconds. Attempts to stand up were noted 394 seconds after the end of CO_2 exposure and were evaluated as complete regain of consciousness (Table 1).

Table 1. Time for return of physical reflexes in pigs recovering after CO_2 stunning.

Reflexes (n=195)	Corneal	Ciliar	Regular respiration	Excitation	Nystagmus	Spontaneous eye blinking	Spontaneous movements	Attempts to stand up
Average (seconds)	45	54	71	78	85	98	174	394
S.D. (seconds)	32	35	34	35	33	52	101	276
% with reflex	100	100	100	77	42	100	100	88[1]

[1]) before limit time 900 seconds.

The fastest appearance of corneal reflex was 16 seconds after the end of CO_2 exposure and the slowest was 257 seconds. 69 pigs (33%) showed corneal reflex within 30 seconds of the end of exposure (Table 2). There was a considerable variation in observations of physical reflexes, and in all cases the results were not normally distributed but skewed towards the higher levels.
87.5% of the pigs showed attempt to stand up before end of the resting period, i.e. within 15 minutes (900 seconds). 15 pigs (7.2%) died during stunning.

Table 2. Distribution of pigs showing corneal reflex at different time intervals after the end of exposure to CO_2.

Interval (seconds)	<10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	111–120	>120
Number	0	13	56	46	27	17	13	8	4	3	3	2	4
Percent	0	6	27	22	13	8	6	4	2	1	1	1	2

Discussion

In a previous investigation, with the same total time of exposure to CO_2 and similar paternoster simulation, it was found that no pigs showed corneal reflex within 30 seconds of end of CO_2 exposure (Holst, 1996, unpublished material). The only difference between the two experiments was the CO_2 gradient through the pit. In the earlier investigation the CO_2 concentration in the first position was measured to be 79–84% and in the bottom position to 90–93%. Thus, the gradient was higher, especially in the upper part of the pit. In an earlier investigation 1.5% of the pigs showed corneal reflex within 30 seconds after 110 seconds of exposure to CO_2, and 9.5% after exposure for 100 seconds (Holst, 1996, unpublished material). The differences in time to occurrence of corneal reflex in the two investigations indicate, that alterations in the CO_2 gradient in the pit may be of greater importance to stunning and the duration of the unconscious phase than alterations in the total holding time in the gas mixture. This may also explain why the distribution of results were skewed towards higher levels in this investigation but not in the earlier investigation.
Under practical conditions at an abattoir it is impossible to evaluate more than a few of the mentioned reflexes. The best reflexes to be used are corneal reflex, ciliar reflex, regular respiration and spontaneous blinking of the eyes which are seen in all pigs. It was found that regular respiration occurred just under half a minute after the corneal reflex, and after another approximately half minute spontaneous blinking of the eye occurred. Forslid (1987) found that 6 pigs exposed twice to 80% CO_2 for 60 seconds showed regular respiration 30–60 seconds after the end of exposure and head movements after 2–3 minutes as the first sign of returning motoric control. Based on recordings of EEG, Forslid (1987) furthermore found, that the pigs were anaesthetised below the level of surgical anaesthesia as defined by Thurmon et al. (1996) for about one minute after end of CO_2 exposure and must have remained anaesthetised and insensible to pain for at least one minute longer, or until a time just prior to spontaneous movements.
The death of pigs actually occurs due to exsanguination. It has been recorded, that insensibility occurs 15 to 30 seconds after sticking, when the major arteries to the brain are severed (Blackmore et al., 1988). This means, that with a safety margin of 60 seconds from sticking to expected insensibility, the sticking must be performed 45 seconds to one minute before the occurrence of regular respiration to ensure that the pigs remain unconscious during sticking and bleeding. In practice the pigs will then be stuck in the very deep stage of anaesthesia, at the latest at the time when the corneal reflex occurs.
Commercial CO_2-equipment varies widely with respect to technical design and operation. This makes it impossible to set up general rules/recommendations for CO_2-concentrations, total time of exposure and stun-stick intervals to ensure safe and, from the point of view of animal welfare, good stunning. Instead it must be recommended, that the physical reflexes mentioned above are used for evaluation of the stunning procedure.

Conclusion

Alterations of the CO_2 gradient in the pit may be more important for the stunning process than alterations in exposure time.
Sticking must be performed in the very deep level of anaesthesia to ensure a safety margin of 60 seconds where pigs remain unconscious until death occurs as result of exsanguination.
At abattoirs a practical evaluation of the efficiency of CO_2 stunning at the time of sticking can confirm a "Good Stunning Practice" if:

- as few pigs as possible (preferably less than 10%) have corneal reflex
- no pigs show deep or regular respiration
- no pigs show spontaneous movements except for single leg movements
- no pigs show spontaneous blinking of the eyes

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