AIR PRESSURE STUNNING OF BROILERS - CHANGES IN THE SPONTANEOUS ELECTROENCEPHALOGRAM, IMMOBILISATION AND HAEMORRHAGING ASPECTS -

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Keywords: air pressure stunning, electroencephalogram, convulsions, immobilisation, haemorrhaging, broilers

Background

Research during the last 15 years indicates that the electrical current necessary to induce unconsciousness in broilers is much higher than that applied in commercial practice. In a waterbath a minimum electrical current of 120 mA per bird is required to irreversibly abolish the brain function and induce a cardiac arrest in at least 90 % of the birds (Gregory and Wotton, 1990). This minimum current for stunning broilers proposed by the Council of Europe increases the quality defects (haemorrhages, broken bones) of carcasses and broiler meat (Veerkamp and de Vries, 1983; Gregory and Wilkins, 1989). The industry is reluctant to use a high stunning current because the increase in quality defects results in enormous losses to the poultry industry. It is apparent that there is a conflict between welfare and meat quality under the conventional electrical waterbath stunning procedure. Therefore, it is necessary that alternative methods for stunning broilers are explored.

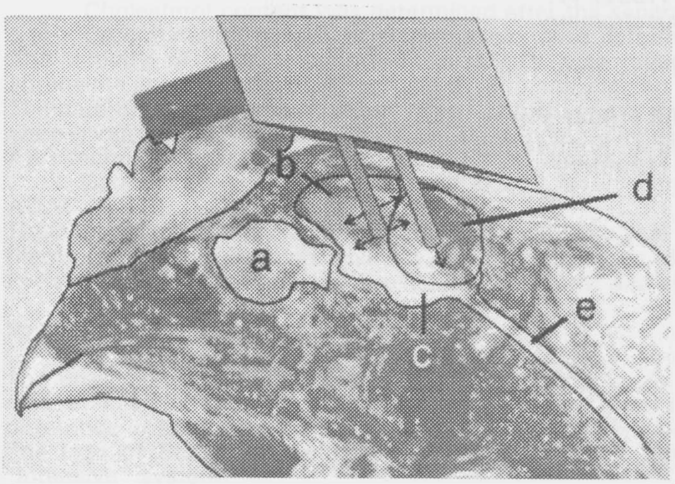
The development of captive bolt stunning, a mechanical method commonly used for stunning of mammals, has been negated for poultry due to lack of means to prevent post-stun convulsions. Nevertheless, captive bolt stunning is a promising alternative to the conventional electrical stunning procedure of broilers with respect to haemorrhaging. Previous work (Hillebrand et al., 1996) has shown that captive bolt stunning in a cone, compared to electrical waterbath stunning of shackled broilers, results in a lower degree of haemorrhaging in breast and thigh muscles. Reducing the number and intensity of convulsions is considered positive, even though haemorrhaging or bird welfare are not necessarily negatively affected by it, as convulsions could be objectionable on aesthetic grounds. Moreover, a motionless animal is required at time of neck cutting. Recently, a modified captive bolt stunning method for broilers has been developed, in which air pressure is used to block post-stun convulsions.

The **Objective** of this study was to determine the effectiveness, by means of electroencephalography, of an air pressure stunning method for broilers, after the time and pressure combination resulting in the lowest degree of convulsions was established. In addition, the effect on muscle haemorrhaging of the air pressure stunning method and the conventional electrical waterbath stunning was compared.

Methods

Air pressure stunning: A modified captive bolt, originally developed for rabbits (Goldhaser Schiessapparat, Brutmachine Jahne Gmbh, Hammelburg, Germany), was used for stunning broilers in this study. The large blunt bolt of the original design is replaced by two smaller bolts (needles), which penetrate the skin and skull at an angle of 35° in caudal direction. Both needles are provided with small holes, which allow air through (Figure 1). The compressed atmospheric air administered through the needle, placed more anterior on the broiler's head, damages fore and mid brain regions to provide unconsciousness, while the other needle (placed 6 mm posterior to the first needle and penetrating the skull just anterior to the bregma) damages medulla oblongata and upper spinal cord to prevent post stun convulsions. A microswitch automatically starts the injection of compressed atmospheric air when the needles penetrate the skull, and the duration of air injection is electronically controlled. The duration of the injection as well as the air pressure can be adjusted.

Experimental setup: In an experiment 48 broilers were slaughtered using 3 different stunning methods. The broilers were caught and transported to the pilot plant the day before slaughter. Feed was withdrawn 10 h prior to start of the experiment. Broilers were randomly assigned to one of the stunning methods. Sixteen broilers (live weight 1.7 ± 0.1 kg) were shackled by their feet and individually electrically stunned in a saline waterbath (4.0 ± 0.1 s, 50 Hz, 109 ± 13 mA), 16 broilers (live weight 1.6 ± 0.2 kg) were air pressure stunned with an injection time of 0.5 s using an air pressure of 2 atm, and 16 broilers (live weight 1.7 ± 0.1 kg) were air pressure stunned during 1 s using 1.5 atm. The air pressure stunned broilers were restrained in a cone during stunning. After all stunning methods the broilers were immediately transferred to a stand equipped with a shackle, and shackled by their feet. Neck cutting was performed 10 to 15 s after the start of every stunning procedure. The time of exsanguination was 3 min.



<Figure 1. Air pressure stunning design positioned on the head of a broiler (sagittal section). a = eye, b = cerebrum, c = medulla oblongata, d = cerebellum, e = spinal cord, arrows indicate holes for compressed air.

Muscle reactions: The stand with the shackled bird was fixed on a Mettler PM30 balance to objectively determine the intensity of post-stun muscle reactions (convulsions). Only unstable weight data (force changes as a result of convulsions) and corresponding time upto 3 min after stunning were filed using Labiel software (developed at ID-DLO by C.H. Veerkamp). Relative weight data [changes in weight (force) relative to broiler live weight] were plotted against time. The area under the graph was computed, expressed as a percentage of the average area under the time-force plot produced by original captive bolt stunning, and used as an objective measure of duration and intensity of post-stun convulsions. Simultaneously, the muscle reactions of the broilers were recorded on a videotape and afterwards the degree of convulsions was subjectively scored in 30-s periods upto 3 min after stunning. Score 1 represents no convulsions, score 2 represents moderate convulsions, and score 3 represents severe convulsions in a 30-s period. For each broiler the scores of 6 30-s periods were added up and finally resulted in 5 classes. Sums of the 30-s scores never exceeded 5 in this study.

Scalding (4 min, 50°C) and plucking was done automatically. After evisceration the birds were packed in plastic bags and stored at 2°C. At 1 day post mortem the carcasses were cut-up and haemorrhages in breast and thigh muscles were scored.

Haemorrhages: Haemorrhages in breast (dorsal side of *Mm. pectoralis major* and *minor*) and left and right thigh muscles (medial side) were quantified by a visual grading system. For classification, a threshold model was used, consisting of a discontinuous 5-point scale with 4 cutoff points (photographs of muscles showing a particular severity of haemorrhages). Class 1 represents haemorrhage-free muscles and class 5 represents muscles with numerous and severe haemorrhages.

Electroencephalograms / electrocardiograms: In a separate experiment 16 broilers were anaesthetized (2 cc Nimatek[R] + 0.3 cc Nembutal[R] per animal) and 3 steel electrodes with a length of 3 mm were implanted in the skull to measure brain activity by means of an electroencephalogram (EEG). The positive and negative electrodes were placed on the line connecting the caudal eye corners; one electrode was placed on the left side of the skull, another electrode was placed on the right side. The earth electrode was placed 6 mm posterior to the electrode on the right side of the skull. All three electrodes were placed 8 mm lateral to the saggital suture to prevent damage to the electrodes as a result of the penetration of the captive bolt needles into the skull. The following day the broilers were subcutaneously equipped with ECG (electrocardiogram) needle electrodes. Then the broilers were air pressure stunned (0.5 s, 2 atm) while placed in a cone. Neck cutting was performed within 10 s after the stun. The EEG and ECG were recorded 1 min before, and upto 3 min after stunning and analysed afterwards. The behaviour of the animals upto 3 min after stunning was recorded on a videotape.

Statistical analysis: The effect of stunning procedure on the relative force of muscle reactions was analysed with ANOVA. Subjective muscle reaction scores and haemorrhaging data were analysed with a threshold model. The model is fitted by the method of maximum likelihood (McCullagh, 1980), employing standard facilities from Genstat 5 (1993). Pairwise comparisons are made on the underlying scale, assuming approximate normality for the estimated effects.

Results and Discussion

Muscle reactions: Measuring subjective scores of post-stun convulsions and relative muscle reaction forces induced by different stunning methods gave similar results for the intensity of muscle reactions (Table 1). Both methods for measuring muscle reactions indicated a significantly ($P \leq 0.05$) higher degree of convulsions after air pressure stunning than after electrical stunning. However, air pressure stunning reduced post-stun convulsing to about 12 to 13 % of the level of convulsions observed after the original captive bolt stunning. It is generally known that the removal of inhibitory influences from higher centres of the brain (for example damaged by captive bolt), before the spinal cord becomes anoxic, results in convulsive activity and enhanced spinal reflexes. After decapitation convulsions only occur when the cut is made cranial to the fifth thoracic vertebra, while cuts caudal to this location result in paralysed animals (Eichbaum et al.1975). Apparently, the air pressure stunning method, which applies compressed air in the direction of the spinal cord, damages this location sufficiently to reduce convulsing substantially. The two air pressures and injection times used in this study were the optimal combinations to ensure the lowest degree of convulsions feasible with this stunning method while using a minimum level of air injection (unpublished data). No difference in the intensity of muscle reactions was observed between these two air pressure combinations.

Haemorrhages: Both air pressure stunning methods resulted in significantly ($P \leq 0.05$) lower breast and thigh muscle haemorrhaging scores than electrical waterbath stunning (Table 1). In pigs mechanical stunning using a waterjet resulted in less haemorrhages in the shoulder than electrical stunning (Lambooy and Schatzmann, 1994). Clonic convulsions observed after the mechanical stunning methods were generated by the brain or spinal cord and may be milder, and hence cause less muscle haemorrhaging, than the tonic muscle contractions induced by direct stimulation during electrical whole body stunning. Rupture of blood vessels as a result of contractions of antagonistic muscles, supercontracion of myofibrils, or movements between muscles after electrical stunning may be intensified by the unnatural position of the shackled bird (Lambooy and Sybesma, 1988). The two air pressure combinations used in this study did not result in differences in thigh haemorrhaging scores. Haemorrhaging scores for breast muscles were significantly ($P \leq 0.05$) lower after air pressure stunning with an injection time of 0.5 s using an air pressure of 2 atm than after stunning with an air pressure of 1,5 atm during 1 s. Since muscle reactions did not differ for the two air pressure combinations, the 2 atm / 0.5 s combination was selected for electrographic studies based on the favourable breast muscle haemorrhaging results.

Electroencephalograms / electrocardiograms: Six broilers were excluded from the experiment due to technical problems with the fixation of the electrodes. In the EEG recording of the other 10 broilers high amplitude, low frequency activity [delta (< 4 Hz) and theta (4-8 Hz) waves] was present or electrical activity was absent immediately after air pressure stunning with 2 atm and an injection time of 0.5 s. In 9 broilers the EEG became isoelectric within 15 s, and in 1 broiler the signal became isoelectric 27 s after stunning. Post mortem macroscopic examination indicated severe disruption of brain tissue. The induction of unconsciousness is induced by laceration, crushing and/or shockwaves. Direct activation of nociceptive (pain sensitive) nerves results in immediate reflexion movements, on the other hand, the mechanical disruption of tissue does not instantaneously result in pain perception. Between the stimulus of tissue injury and the subjective experience of pain there is a chain of complex chemical and electrical events (Gybels, 1992). Three of the 10 broilers exhibited brief (10 to 20 s) tetanic spasms after stunning, however no withdrawal reflexions were observed. The remaining 7 birds were motionless immediately after stunning. The ECG recordings of the broilers show an irregular pulse immediately after stunning, followed by the appearance of an ST-deviation and finally extinguishing of the signal. In this study with a limited number of animals the rapid induction of isoelectric activity and the profound damage to brain tissue suggest instantaneous unconsciousness after air pressure stunning. In a following study damage to vascular and nervous tissue will be determined more specific using histological techniques.

Table 1. Muscle reaction and haemorrhage scores means and standard deviations of broilers either electrically waterbath-stunned while shackled or air pressure stunned in a cone, using two air pressure values and two injection times (n = 16 per stunning-restraining treatment).

Stunning treatment Restraining treatment	Electrical waterbath 4 s, 50 Hz, 109 (±13) mA Shackled	Air pressure 2 atm, 0.5 s Cone	Air pressure 1.5 atm, 1 s Cone
Muscle reactions, relative force (%)	2.2 ± 1.2^{b}	12.4 ± 9.7^{a}	13.3 ± 11.2^{a}
Muscle reaction score	0.0 ± 0.0^{b}	1.8 ± 1.0^{a}	1.8 ± 1.4^{a}
Breast haemorrhage score	3.1 ± 1.1^{a}	1.6 ± 1.0^{c}	2.3 ± 0.9^{b}
Thigh haemorrhage score	3.9 ± 1.0^{a}	2.1 ± 1.2^{b}	2.6 ± 1.4^{b}

[a,b,c] Means within rows with no common superscript differ significantly ($P \leq 0.05$).

Conclusions

Preliminary results indicate that air pressure stunning sufficiently mechanically damages the brain to result in immediate unconsciousness and therefore is an effective preslaughter stunning method for broilers. Air pressure stunning largely suppresses the convulsions occurring after original captive bolt stunning, and results in less haemorrhages in breast and thigh muscles than conventional electrical waterbath stunning of broilers.

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