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Restraining and neck cutting or stunning and neck cutting of veal calves

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ABSTRACT

Brain and heart activities were measured in 31 veal calves during restraining and rotating followed by neck cutting with or without stunning to evaluate welfare.
After neck cutting Correlation Dimension analyses and %power of EEG beta wave fraction decreased gradually to lower values resulting in an induction of unconsciousness lasting on average 80 s. Corneal reflex response ceased 135 ± 57 s after neck cutting. The CD scores and the %power of beta waves fell immediately after post-cut captive bolt and pre-cut electrical stunning to levels indicating unconsciousness.
Heart rate in lairage increased upon entrance to the restrainer and again after rotation, heart rate variability decreased.
Rotating the restrainer 90°, 120° or 180° compromised veal calf welfare and should be avoided. It is recommended to use post-cut captive bolt stunning or pre-cut electrical stunning inducing immediate unconsciousness.

1. Introduction

According to the EU Council Regulation (2009) on the protection of animals, at slaughter, they should be a) properly housed, b) restrained during the slaughter process and c) stunned before slaughter. Animals must be restrained in an appropriate manner, so as to spare them any avoidable pain, suffering, agitation, injury or contusions. Placement in the restrainer is potentially stressful and requires additional attention from the operator. Fear is a major cause of stress in cattle due to the new environment and the fixation of the body. (Grandin, 1997; von Wenzlawowicz & von Holleben, 2007). The degree of fear is related to the breed, sex, age and experience of the animal. The animal can be calmed by the operators and accompanying animals (Grandin, 1997; von Wenzlawowicz & von Holleben, 2007). Cattle are neck cut in the restrainer in a standing position or rotated in the restrainer (e.g. Weinberg apparatus). Blood cortisol values have been seen to increase and O_2 saturation to decrease significantly after rotation to 180° (Dunn, 1990; Tagawa, Okano, Sako, Orima, & Steffey, 1994). The Federation of Veterinarians in Europe (FVE) has proposed prohibition of the 180° rotation (FVE, 2005). They suggest that pressure from the intestines on heart and lungs after inversion through 180° can provide additional stress. Permitted methods for stunning are 1) captive bolt pistol, 2) concussion, 3) electro-narcosis and 4) exposure to approved gas mixtures. European Union legislation makes an exception to stunning for ritual slaughter. Some Halal groups do not accept any form of stunning whereas others accept captive bolt stunning post-cut or electrical stunning pre-cut. Ritual slaughter requires the animal to be unharmed before slaughter and captive bolt or electrical stunning may be considered to render the animal imperfect and unacceptable.

Captive bolt stunning methods aim to cause tissue damage by transmitting the energy from the missile to the brain. In general, penetration of a missile into the brain can cause injury in one of three ways, depending on its velocity and shape: by laceration and crushing (<100 m/s), by shock waves (about 100 to 300 m/s) and by temporary cavitation (>300 m/s) (Hopkinson & Marshall, 1967).

Missiles used for stunning and killing of animals include a bullet, a bolt, water jet and compressed air. Immediately after penetration the animals express a tonic spasm for approximately 10 s prior to relaxation, however, excessive convulsions may occur (Eichbaum, Slewer, & Yasaka, 1975). When immediately after shooting major changes (delta and theta waves tending toward an iso-electric line) are seen on the EEG (electro encephalogram) it is assumed that the animal is unconscious by analogy to similar EEG changes described in humans (EFSA, 2004; Lambooy, 1982; Lopes da Silva, 1983). Immediately after captive bolt stunning veal calves also express a tonic spasm for approximately 10 s prior to relaxation, however, excessive convulsions often follow (Lambooy & Spanjaard, 1981).

Electrical stunning is a commonly used method for farmed species, however use is limited for cattle. It involves electrical stimulation of the brain by placing electrodes on either side of the head, or on the head and body so that current passes through the brain and heart. It is important that an adequate voltage is used to drive sufficient current through the animal. This stimulation of the brain causes the equivalent of a generalized epileptiform brain activity accompanied by seizures indicative of unconsciousness and insensibility (Lambooij, 2004). The epileptic process is characterized by rapid and extreme depolarization

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of the membrane potential and development of a synchronized electrical response. This can be measured and observed on the recorded EEG as such an insult produces relatively small waves increasing in amplitude during the tonic phase (rigid), and decreasing in frequency in the clonic phase (high motor activity in muscles) resulting ultimately in a period of strong depression of electrical activity in pigs, sheep and calves (Anil, 1991; Anil & McKinstry, 1992; Lambooy, 1982). An eye-reflex cannot be used as an indicator, because the reflex is blocked during the tonic phase and may occur spontaneously during the clonic phase (Roos & Koopmans, 1936). During epilepsy the brain remains in a highly stimulated state being unable to respond to stimuli.

The aim of this study was to measure brain and heart activity during restraining and rotating the animal through 90°, 120° or 180° and after just neck cutting, post-cut captive bolt stunning and pre-cut electrical stunning to evaluate the effects on animal welfare and induction of unconsciousness. In addition, blood values related to energy metabolism were measured and analyzed.

2. Materials and methods

2.1. Animals

Thirty-one veal calves delivered at the slaughterhouse from different commercial farms from mixed breeds (red or black and white) were randomly selected from groups in lairage. It was possible to perform experiments with approximately 4 to 6 animals per day divided over 7 days. Carcasses were weighed after slaughter and warm slaughter weight averaged 185 ± 26 kg.

2.2. Experimental design

At the start of the experiment the animals were placed in a holding pen within the lairage area and restrained individually to sample blood and equip them with EEG and ECG electrodes. After the preparations in the holding pen each calf was driven to the V-type restrainer, blood sampled once again, fixed-head restrained, rotated and immediately either neck cut or neck cut and captive bolt stunned or stunned electrically and neck cut (Table 1). Blood was sampled during exsanguination. In the 2 min after the cut the corneal reflex was measured every 30 s (except after electrical stunning), thereafter the calf was expelled from the restrainer, bled out further and slaughtered. Rotation and stunning procedures were allocated at random to each calf prior to the first slaughter.

Blood was sampled from the vena in the tail (*V. caudalis media*) (70 μml). Immediately after sampling, the blood was analyzed using an ABL80 Flex (Radiometer Medical ApS Brønshøj, Denmark)

The following parameters were analyzed:

pH	acidity or alkalinity of the venous blood
pCO_2	pressure of carbon dioxide in the venous blood
pO_2	pressure of oxygen in the venous blood
sO_2	saturation of oxygen in the venous blood
BE	base excess (indication of acidity/alkalinity in the blood)
Hb	hemoglobin content
Ht	hematocrit
Glucose	level of glucose in the venous blood

Table 1
Rotating and neck cutting or stunning and neck cutting procedures.

Rotation	Neck cutting/stunning	N
90°	Neck cutting	3
	Neck cutting followed by captive bolt	5
	Electrical stunning followed by neck cutting	3
120°	Neck cutting	4
	Neck cutting followed by captive bolt	4
	Electrical stunning followed by neck cutting	3
180°	Neck cutting	3
	Neck cutting followed by captive bolt	3
	Electrical stunning followed by neck cutting	3

A tracking unit designed by the Royal Veterinary College in London (Lowe, Abeyesinghe, Demmers, Wathes, & McKeegan, 2007) was used for EEG and ECG measurements, at a sample speed of 250 Hz on each channel. The measuring device was placed in a steel box covered by a leather bag attached to an elasticated belt and coax cables connected the tracking device to the pads (being a cage of Faraday). Electrode pads were attached to the skin after an area had been shaved and cleaned with 70° alcohol. Surgical glue was applied to secure the electrode pads to the surface of the skin. The EEG electrode pads were placed on the skin of the skull: one electrode 2 cm to the right and one electrode 2 cm to the left of the sagittal suture and 3 cm of the imaginary transverse line at the caudal margin of the eyes. The ECG electrodes were placed caudal the olecranon on both sides of the chest. The earth electrode for both EEG and ECG was placed on the chest dorsally to the left electrode. Recording started immediately after the measuring equipment had been fitted in the holding pen and ended after the animal was expelled from the restrainer. Both EEG and ECG were recorded from moment of activation of the tracking equipment until 2 min after neck cutting. The EEG and ECG recordings were later analyzed for changes in the waveforms, frequency and suppression.

The electrical activity recorded on the EEG can be classified into delta (0–4 Hz), theta (4–7 Hz), alpha (8–13 Hz) and beta (>13 Hz) frequency bands. In alpha and beta rhythms, the animal is considered conscious (Kooi, Tucker, & Marshal, 1978). The EEG signals were computed by FFT (Fast Fourier Transform) (LabChart7 Pro. V7.1.2, AD Instruments, Cologne, Germany). The power spectrum was calculated by means of 512 points with an input averaging factor of 5 and a power smoothing factor of 32. An FFT was computed before and after neck cutting.

The ECG was analyzed for heart rate in beats per minute and heart rate variability i.e. the LF/HF ratio. This is the ratio of the absolute powers in the low frequency and high frequency bands (Malik, 1996).

Once in the V-type restrainer the head was restrained and the calf rotated to either 90°, 120° or 180° (Table 1).Thereafter the animal was either neck cut, was post-cut stunned by captive bolt (Cash Bull-dozer .25; Accles & Shelvoke, West Midlands, UK), or was pre-cut stunned electrically with 300 V for 3 s . Electrical power supply (Stork RMS, Lichtenvoorde, Netherlands) was delivered at a constant voltage (50 Hz a.c., sinusoidal).

2.3. Ethics

The experiment was approved beforehand by the Ethical Committee of the Animal Sciences Group of Wageningen UR.

2.4. Statistical analyses

The EEG traces were subjected to correlation dimension (CD) analysis. The CD analysis computes FFT and provides a non-linear (fractal) measure of signal complexity (for algorithm see van den Broek et al., 2005). Correlation dimension analysis is a relatively new technique that has been customized to measure depth of anesthesia in humans (van den Broek, 2003). The small amplitude, high frequency (awake) EEG signal is more complex than the large amplitude, low frequency (unconscious) EEG signal. Therefore, high CD values are taken to indicate awareness while low values indicate a state of unconsciousness. It is suggested that a reduction in CD to 60% of the baseline value is an indicator of unconsciousness (van den Broek, 2003).