Stunning of pigs with a high pressure waterjet

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SUMMARY: A pump apparatus designed to produce a high pressure waterjet (1000 bar; 17 l/min) was used in pilot experiments which were conducted to examine its potential use as a stunning method in slaughter pigs.

On three intact heads of pigs, obtained early post mortem, the nozzle of the pistol was positioned frontally on the head and at 10 cm distance. The waterjet was applied for 3 and 1 s. The diameter of the drilled hole in the skin and skull was less than 0.5 mm, while the dura mater was not visually damaged. The time needed to drill through the skin and skull was 0.2 to 0.4 s.

Judged from the EEG recordings all 10 slaughter pigs were stunned immediately after application of the waterjet during 1 s. Seven pigs were fully relaxed after the treatment, two pigs showed weak and one pig some strong convulsions. In 2 out of 20 shoulders a minimal blood splash was observed the day after slaughter.

It is suggested that application of the high pressure waterjet causes damage to the brain which induces immediate unconsciousness. The waterjet technique may possibly further developed into a practical stunning method.

INTRODUCTION: In history, farm animals have long been killed without stunning or stunned by a blow on the head. During the 19th century concern for animal welfare had grown and these methods were considered as unsatisfactory. Captive bold stunning was introduced at the end of the 19th century (FAHRBACH, 1948), electrical stunning at the end of the twenties (MÜLLER, 1929) and CO_2-stunning in the fifties (WERNBERG, 1978) of the present century. All these stunning methods have disadvantages both from the welfare and meat quality point of view. A correct positioning of the captive bolt pistol in pigs is difficult to realize and debleeding and shackling are difficult to performe because of the convulsions which occur. The method cannot be recommended for general use. Although, certain electrical and CO_2-stunning methods are acceptable from the welfare point of view, neither is perfect (LAMBOOY, 1990). Haemorrhages in muscles of carcasses of slaughter pigs were observed after the introduction of electrical stunning (ANTHONY, 1932). These haemorrhages were not only observed after electrical stunning, but also after concussion, captive bolt and CO2-stunning methods, altough not always to the same extend and at the same locations. Compared with the last mentioned stunning methods electrical stunning caused most heamorrhages. The haemorrhages were found in muscle, connective and fat tissue (KIRTON et al, 1981; BURSON et al, 1983).

To improve animal welfare and meat quality better stunning methods should be developed. A very high pressure waterjet which is applied during miliseconds is in development (LEUENBERGER, 1989; SCHATZMANN et al, 1990). A high pressure waterjet for cutting and drilling in solid materials became recently available, which may be suitable for stunning of animals. The aim of these pilot experiments was to examine the posibility of a high pressure waterjet for the stunning of slaughter pigs.

MATERIALS AND METHODS: A transportable pump apparatus, designed to produce a high pressure waterjet (Mourik b.v., Rotterdam), was used in the experiments. The pressure of 1050 bar was applied via tubes to a fixed pistol. The nozzle of the pistol had an output opening of 1 mm and allows cutting and drilling with the waterjet. When in operation 17 l water/min. was realised from the nozzle.

In a slaughterhouse 3 heads of pigs were decapitated directly after debleeding. The heads were fixed on a table, while the pistol was fixed in a stand frontally of the heads. The nozzle was positioned on the skin in the first 2 heads, while the waterjet was applied during 1 and 3 s, respectively. In the third head, the nozzle was positioned at a distance of 10 cm from the skin, while the application time was 1 s. The whole procedure was recorded on video, which was analised after the experiment.

In the second pilot experiment the pump apparatus was placed outside the slaughterhouse. For stunning the animals the pistol was fixed in a stand frontally to the head of the pig. The waterjet was applied during 1 s. Ten slaughter pigs (crossbred; 5 castrates and 5 gilts, live weight approx. 105 kg) were involved in the experiment. Before stunning the pigs were restrained on a double rail. In the last 5 pigs iron electrodes for recording the EEG (electro-encephalogram) and ECG (electro-cardiogram) were attached to the head and body of the animals. The electrodes were placed 2 cm lateral on both sides of the sagittal suture and 3 cm caudal a line extending between the caudal eye corners. The ECG needle electrodes were fixed in place subcutaneously one in the chest behind the elbow and one at the same height on the back. The earth needle electrode was placed behind the ear and used both for EEG and ECG recording. The EEG and ECG were recorded just before stunning, during and for 1 min after stunning. Both recordings were analysed afterwards. The behaviour of the animal was monitored by video.

The day after slaughter the shoulders were derinded, deboned and scored for haemorrhages according the method described by LAMBOOY & SYBESMA (1988).

RESULTS: In the first experiment the waterjet cut and drilled immediately through the skin and skull of the head of the pig. The diameter of the drilled hole in the skull was less than 0.5 mm. After opening the skull the dura mater showed no macroscopical signs of damage. Videoanalysis showed that the time to drill through the skin and skull of the head was 0.2 to 0.4 s.

In the second experiment application of the waterjet frontally on the head of a pig resulted in an immediate muscle relaxation in 7 animals. In 2 animals some weak convulsions and in 1 animal strong convusions occurred after stunning. The corneal reflex was absent in all pigs after the treatment. The EEG showed an immediate occurrence of delta waves (<4 Hz) and spikes or no electrical activity.
The heart rate (n=5) was before, 30 s and 60 s after the treatment 94±9, 314±18 and 127±65 beats/min, respectively. The ECG recordings showed that in 4 out of 5 animals the heart was fibrilating 30 s after treatment. One animal showed bradycardia with an irregular rhytm.

At post mortem examination the brain was fully destroyed and the brain cavity was empty in 5 pig heads. In the same pigs no electrical activity was recorded on the EEG after the treatment. In 3 brains severe haemor-

rhages were observed. In 2 of these pigs equipped with EEG electrodes delta waves and spikes were observed on the recording.

The day after slaughter a few minimal heamorrhages were found in 2 shoulders from different animals. One haemorrhage was found in the m. triceps brachii and 2 in the connective tissue between the m. triceps brachii and m. infra spinatus.

DISCUSSION: The present regulations of the Dutch "MEAT INSPECTION ACT" (1919) prescribe, that stunning occurs by means of (a) instruments which mechanically destroy the cortex of the brain, (b) transport of an electrical current through the brains and (c) inhalation of gasses. Both LEUENBERGER (1989) and SCHATZMANN et al (1990) and the results of our experiment suggest that the waterjet can mechanically destroy the brain to such an extend that it causes immediate unconsciousness.

The most important factor causing tissue damage is the energy from the missile transmitted to the brain. Penetration of the missile into the brain can cause injury in the following three ways depending on its velocity and shape: laceration and crushing (low velocity missiles), shockwaves (velocity about 100-300 m/s) and temporary cavitation (velocity over 300 m/s). As brain tissue can scarcely be compressed the cranial volume increases and transmits a pressure increase which prevents further enlargement of the cavity caused by the missile. The cerebral damage is not caused by the sudden development of high pressure, but by the negative pressure of the shockwaves or by the collaps of the brain tissue of the obliteration of the temporary cavity (BUTLER et al, 1945; CROCKARD, 1977).

In the stunning of animals for slaughter the onset of unconsciousness is more important than the nature of the injury. The occurrence of unconsciousness might also be related to the transmission of pressure changes within the skull to the spinal cord or to crush the cortex and deeper parts of the brain (LINDGREN, 1966; LAMBOOY, 1981). According to LEUENBERGER (1989) the pressure needed to penetrate the skin and skull and to crush the brain is ideally between 3500 and 4000 bar by application for 50 to 100 ms. With this waterjet more brain tissue is destroyed than using a captive bolt. In our experiments a pressure of 1000 bar was used with a shape of the waterjet that cut and drilled, while the jet was applied for 1 s. After slaughter the brains were disappeared or severe haemorrhages in the brains were found. Unconsciousness might be induced by laceration, crushing and/or shockwaves. Activation of nociceptive (pain sensitive) nerves result in immediate reflective movements, while mechanical tissue disruption may result in pain after a while (VOORHOEVE, 1980). Videoanalysis did not show any reflective movements of the animals during stunning and the EEG showed after the treatment an immediate change in delta waves with spikes or absence of electrical activity.

Haemorraghes in the carcass seemed to be mainly caused by electrical stunning, although preceeding stress and restraining may also be important factors (JEMMI, 1984; LAMBOOY & SYBESMA, 1988). Rupture of blood vessels might be caused by contractions of antagonistic muscles, super contraction of myofibrils and during movements between muscles (WAL v.d. et al, 1975, LEET etal, 1977, GILBERT & DEVINE, 1982). After stunning with the waterjet in only one animal strong contractions were observed, while the other animals only showed some weak convulsions. As was expected after slaughter only a few haemorrhages were found in the shoulders.

CONCLUSIONS: The results of these pilot experiments suggest that with the high pressure waterjet immediate unconsciousness is induced by injuring the brain by laceration, crushing and/or shockwaves. The results also suggest that it may possibly be feasible to further develop the high pressure waterjet method for application as a stunning method for pigs in practice.

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