The Noxious Effects of Electroimmobilization in Adult Holstein Cows: A Pilot Study

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ABSTRACT

Ten adult Holstein cows were used in an experiment to determine whether the induction of electroimmobilization was a noxious event. The cows were halter trained and accustomed to being led into a set of stocks. The time taken for the cattle to walk the last ten metres into the stocks was recorded. The heart rate of the cow was recorded for a three minute period prior to a ten second exposure to a high pitched sound (the conditioning stimulus). Measurements were collected for three repetitions and then the cows were assigned to two groups of five. One group was immobilized for 30 seconds using a commercial electroimmobilizer, the other group was not treated. This procedure was repeated ten times over a period of eight days. The cows were then exposed to the conditioning stimulus and their response observed. The treated group took significantly ($P < 0.05$) longer to get into the stocks and the regression slopes for heart rate were significantly different from the control group. The treated cows responded to the conditioning stimulus at five and nine months after the end of the conditioning period.

Adult Holstein cows regarded electroimmobilization as a noxious event and were very strongly conditioned to this stimulus.

Key words: Electroimmobilization, electroanesthesia, cows, conditioning stimulus.

RÉSUMÉ

Cette expérience portait sur dix vaches Holstein adultes et elle visait à déterminer si l'induction d'une électro-immobilisation correspondait à une intervention désagréable. On les habitua d'abord à se laisser mener au licou et conduire dans une stalle de contention. On enregistra ensuite le temps qu'elles prirent pour franchir les derniers dix mètres qui les séparaient de la stalle de contention. On enregistra aussi leur rythme cardiaque, durant trois minutes, avant de leur faire entendre, une deuxième fois, un son aigu qui correspondait au stimulus de conditionnement. On répéta les enregistrements précités, à trois reprises, avant de séparer les vaches en deux groupes de cinq. Celles du premier subirent une immobilisation d'une durée de 30 secondes, à l'aide d'un appareil électrique commercial, tandis que celles du deuxième servirent de témoins. On répéta l'intervention, dix fois, au cours d'une période de huit jours. On soumit ensuite les vaches au stimulus de conditionnement et on observa leur réaction. Les vaches du premier groupe mirent significativement ($P < 0, 05$) plus de temps à se rendre dans leur stalle de contention et la courbe de régression de leur rythme cardiaque afficha une différence appréciable, par rapport aux témoins; elles répondirent aussi au stimulus de conditionnement, au bout de cinq et neuf mois après la fin de l'expérience.

Les vaches Holstein adultes réagirent donc à l'électro-immmobilisation comme à une intervention désagréable et elles s'y avérèrent fortement conditionnées.

Mots clés: électro-immobilisation, électro-anesthésie, vaches, stimulus de conditionnement.

INTRODUCTION

Electrical currents have been known to produce analgesia since the times of the ancient Greeks. Scientific research into electroanesthesia started at the beginning of this century (1) and there was considerable interest in this area in the veterinary field in the 1960's (2,3,4). However, conventional anesthetic techniques using drugs were found to be more consistent and to provide better muscle relaxation. It is only recently that further interest has been directed toward electrical immobilization. The development of an electrical device to immobilize cattle was carried out in Australia and is now being marketed in many countries. One of these machines, the "Stockstill" (Feenix International Pty. Ltd., Moor Hatches, West Amesbury, Wiltshire, SP4 7BH, U.K.) immobilizes the animal by putting it into extensor rigidity. As in Leduc's early work with dogs (1), apnea can result from rigidity of the muscles of respiration. The induction of electrical immobilization appears to be stressful to the animal and is reported to be an unpleasant sensation in man (1).

The objectives of this pilot study were to determine if a short period of electroimmobilization was regarded by the cow as a noxious stimulus. The study was designed to measure one autonomic (heart rate) and one behavioural (aversion) response of cows being electroimmobilized compared to cows that were not.

MATERIALS AND METHODS

Ten mature Holstein cows were halter trained over a two week period.

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This project was funded by a grant from the Canadian Veterinary Research Trust Fund.

Submitted August 6, 1985.

The cows were tethered in stanchions and were led from there to a set of stocks down a wide corridor. After the initial training, alligator clip electrocardiogram (ECG) electrodes and a mouth electrode were placed on the cow while she was standing in the stanchion. The mouth electrode consisted of a wide alligator clip which was attached at the commissure of the lips such that the inner part of the electrode made good contact with the buccal mucosa. After eight training days, the cows were accustomed to this procedure and the experiment was started. A line was marked in the corridor and the time taken for the cows to walk the distance from the line and into the stocks (ten metres) was measured using a stop watch. Once in the stocks, a rectal electrode was inserted and the mouth and rectal electrodes were connected to the "Stockstill". The rectal electrode, consisting of a tapered cylindrical piece of stainless steel measuring 10 cm long by 4 cm in diameter, was coated with an electrical conducting gel and inserted into the rectum. The ECG electrodes were connected and a recording of the ECG made over the next three minutes. At the end of this time, the cows were exposed to a high pitched sound for ten seconds (the conditioning stimulus or CS). The cows were then offered a small quantity of grain before being returned to their stanchion. After three repetitions for each animal, the ten cows were divided into two groups of five. The groups were selected to try to make them evenly matched on the basis of temperament. One group was electroimmobilized for 30 seconds following the conditioning stimulus with ten repetitions for each animal over a period of eight days. The electroimmobilizer was turned on at a power level of 8 on the dial (approximately 80 mA). The heart rate was measured using the ECG for a further minute after the immobilization in the treated group. The other group was treated in the same way but they were not immobilized and the heart rate was only measured over the first three minutes.

Three cows from each group were exposed to the CS, while standing in their stanchions, at the end of the experiment and five and nine months later. Their behaviour was observed by the principal investigator.

The "Stockstill" is a battery powered device which produces a 50 volt pulsed direct current (DC) which can be varied from approximately 20-240 mA. The pulse is a square wave with a 10% duty cycle and is set at 50-60 Hz.

An analysis of variance was used to determine whether the two groups were diffferent during the three control sessions. A Student's t test was used for walking time and heart rate to compare the first three control sessions with the last three treatment sessions. Linear regression slopes were calculated for each cow for the walking time and the heart rate over the ten treatment sessions. These slopes were then used to calculate a mean for each group and the means were compared using an analysis of variance. The heart rates measured after the immobilization in the treated group for the first and last three sessions of the treatment were compared using a Student's t test.

RESULTS

There were no significant differences in walking time and heart rate between the two groups during the first three control sessions. When sessions 1, 2 and 3 were compared with sessions 11, 12 and 13 for the treated group, there was a significant difference in the walking time ($P < 0.05$) but the heart rates were not significantly different ($P < 0.1$ but > 0.05) (Figs. 1 and 2). When the same parameters were compared using the analysis of variance over sessions 4-13 (the ten treatment sessions), there was a significant difference ($P < 0.05$) for the regression slopes of both parameters between the treated and control groups (Figs. 3 and 4). The heart rates measured for the one minute after the immmobilization in the treated group were significantly lower for the last three sessions (S11, S12, S13) when compared with the first three treatment sessions (S4, S5, S6) (Fig. 5).

When the cows were exposed to the conditioning stimulus the day after the

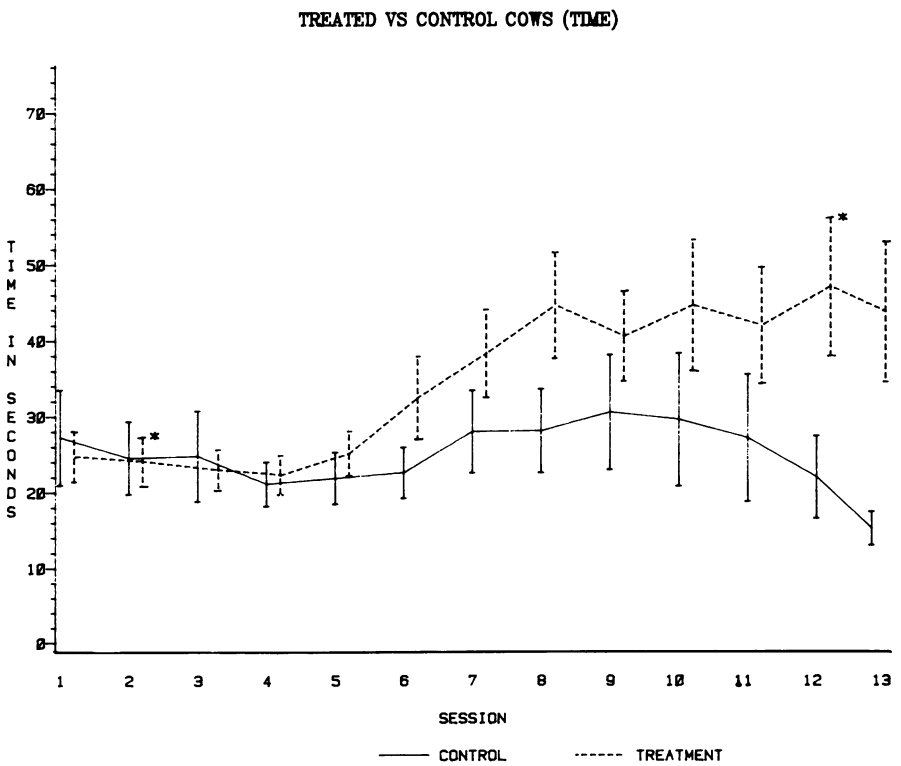

Fig. 1. Time (in seconds) taken for the cows to walk the last ten metres and into the stocks for the three control sessions (1,2,3) and the ten treatment sessions (4-13). The points are plotted as rolling means. The asterisks (*) indicate that the two points are significantly different ($P < 0.05$).

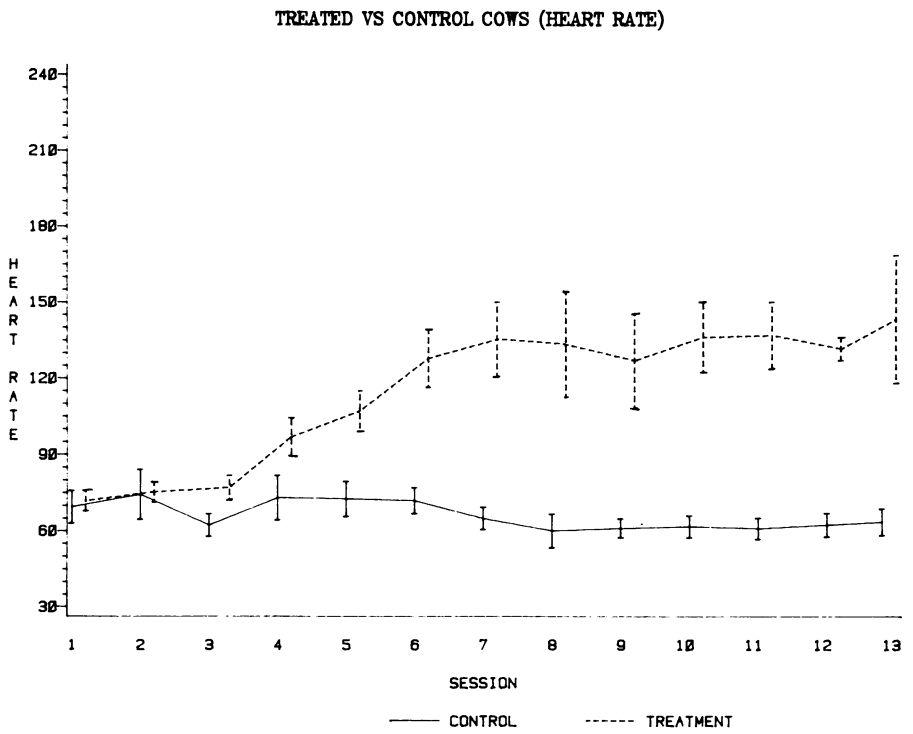

Fig. 2. Heart rate (beats per minute) of the cows during the three minute period before the conditioning stimulus, for the three control sessions (1,2,3) and the ten treatment sessions (4-13). The points are plotted as rolling means.

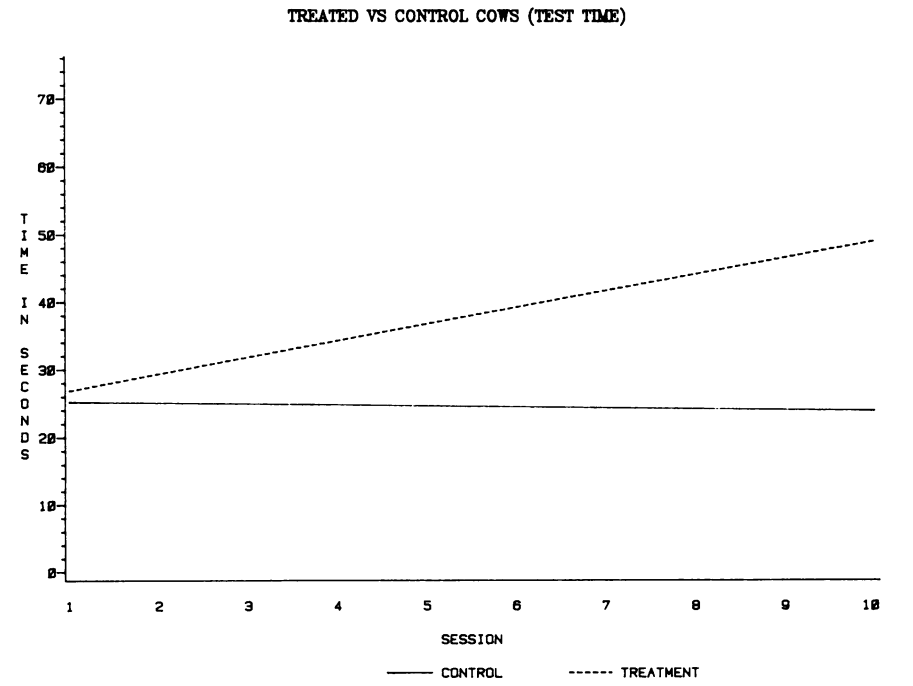

Fig. 3. Mean regression slopes for the two groups during the ten treatment sessions for the time taken to walk the last ten metres and into the stocks. The slopes are significantly different ($P < 0.05$).

last session, five and nine months later, all of the treated animals responded whereas the control cows showed no response. The treated cows backed up in their stanchion as far as the neck gate would allow, they shook their heads, flicked their tails and often exhaled forcefully through the nostril.

DISCUSSION

The use of a conditioning stimulus (CS) paired with an unconditioned electrical current stimulus (UCS), has been described in similar experiments assessing the effect of electrical stunning on sheep (5,6). In the first experiment (5), designed to determine whether stunning at different currents produced unconsciousness, it was found that at low currents, the sheep reacted when the CS was presented without the UCS. When sufficient current was used, the sheep did not become conditioned, suggesting that they had been rendered unconscious or at least amnesic. In the second experiment (6), using a 90 volt alternating current at 50 Hz for varying times, the investigators found that even a three second shock was sufficient to prevent conditioning. Thus the 80 mA and 50 volt DC current produced with the immobilizer in our experiment may have been insufficient to produce the best effect. However, continuing the current for 30 seconds should have been sufficient to produce an anesthetic/amnesic state if this is produced at all by this technique.

Our results indicated that electroimmobilization, at the current used, was a noxious event for the cow. When the last three treatment sessions were compared with the first three control sessions, the heart rate differences were not statistically significant but the measurements of time and the regression slopes of the data were significantly different from the controls. The heart rates and walking times on the control cows continued to show a slightly negative slope indicating that there was still a training effect on these animals. Previous work on this type of immobilizer has concentrated on the biochemical changes during immobilization with and

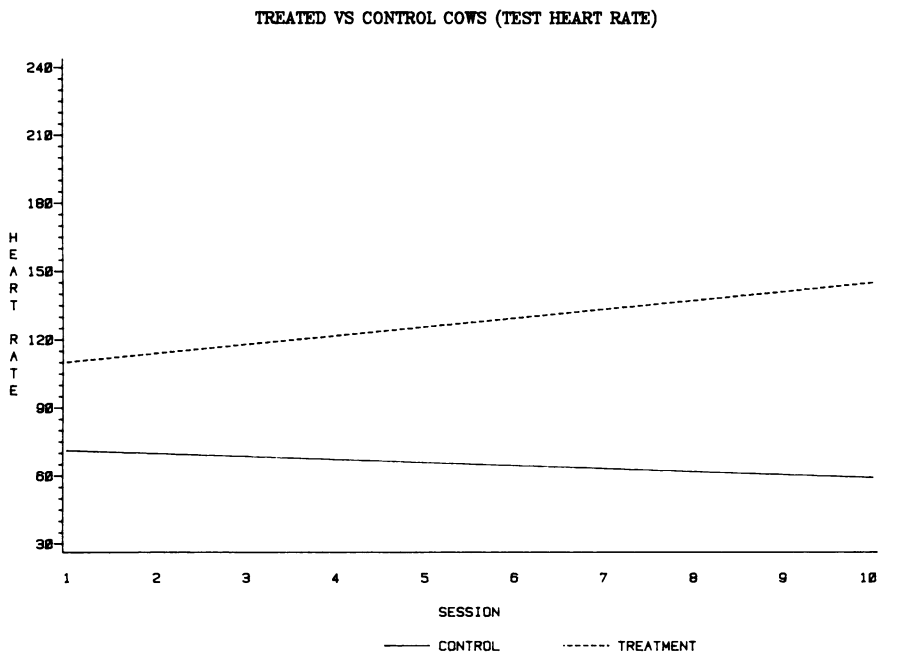

Fig. 4. Mean regression slopes for the two groups during the ten treatment sessions for the heart rate prior to the conditioning stimulus. The slopes are significantly different ($P < 0.05$).

without the stress of a painful stimulus (7, 8, M.A.E. Rex, unpublished observations). No assessment has been made of the stress associated with the induction of immobilization. In other experiments investigating the effect of "stray" voltages associated with milking machinery, it was found that currents as low as 4 mA at 1.8 volts applied to the rump could affect the behaviour of the cow. On average a current of 4.6 mA was enough to elicit a response in the tested cattle (9,10). Thus it is not at all surprising that a current of about 80 mA at 50 volts produced a strong conditioning response, even though the current was being applied in a different manner (pulsed DC applied from the head to the tail versus AC applied from the rump to the foot).

Although the results showed that electroimmobilization was a noxious event, they do not indicate how it would compare with some other common painful stimulus such as an injection, an incision or a hot branding iron. The cause of the aversive conditioning was also not identified; it could have been due to the shock associated with the current being turned on, the resulting muscle spasm, or the affective response to sudden immobilization.

The experiment also demonstrated that this conditioning is remembered well by the cows. The cattle showed a behavioral response (a conditioned emotional response) to the CS for up to nine months after the end of the experiment. Although these cows were conditioned to the current by repeated exposure this memory for the process of immobilization could interfere with handling animals if this method of restraint was used frequently.

The lower heart rates measured after the shock in the treatment group could be explained on the basis of conditioning to the UCS. As the animals learned that the shock was over, they could relax and so their heart rates reduced. However, this result was not repeated in a second group of cows tested subsequently (P.J. Pascoe, unpublished observations).

The measurement of an ECG or an electroencephalogram (EEG) during immobilization was not attempted in this experiment. This requires special electrical filters to remove the externally applied current (11). Recently cardiac arrhythmias have been found in sheep and calves during and after the application of immobilizing current with little or no change in the EEG recorded immediately following a 20 minute period of immobilization

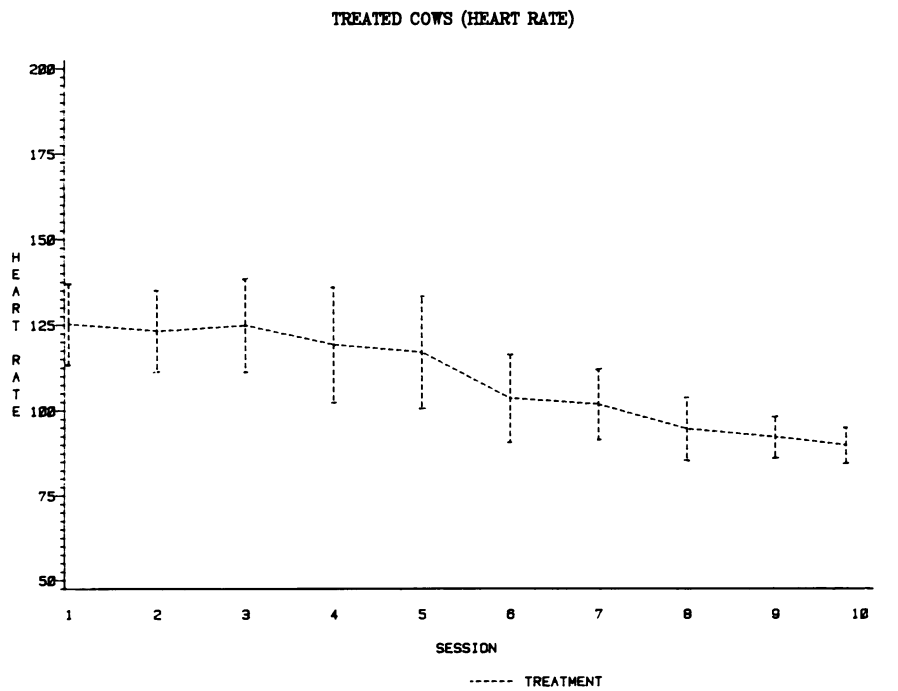

Fig. 5. Heart rate (beats per minute) of the treated cows during the ten treatment sessions taken over one minute immediately after the end of immobilization. The points are plotted as rolling means.

(12). This suggests that the action of the current is to produce immobility without altering cerebral function while adding a certain amount of cardiovascular stress.

Electroanesthesia has been used for many years but the aim has been to produce anesthesia with the best muscle relaxation possible. To this end, an alternating current at 700 Hz was used extensively in the past (2,3) and continues to be used today (13, 14). The use of electric current to immobilize the animal by muscle tetany is a new departure and, according to our results, a noxious event for the cow. This experiment, of necessity, was carried out in trained Holstein cows and the results cannot be applied to an untrained beef cow which may find physical restraint such a noxious event that electroimmobilization would be no worse. Electroimmobilization may also be useful for restraining animals where there are no readily available methods for physical restraint thus providing safety for the operator.

ACKNOWLEDGMENTS

The authors wish to thank Dr. I. Dohoo for his assistance with the statistical analysis of the data.

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