Studies on Slaughtering Procedures in Sheep.

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INTRODUCTION

Between 11 and 14 million sheep are slaughtered annually in the United Kingdom, the majority of which are stunned before being stuck. The effectiveness of this stunning procedure depends on two factors; the duration of the induced anaesthesia and the length of time the anaesthesia should last before the animal has died from loss of blood.

The length of time the anaesthesia should last is equal to the sum of the stunning-to-sticking interval and the sticking-to-brain death interval. This paper gives some preliminary estimates for the stunning-to-sticking interval in commercial abattoirs in England and Wales, and the interval between sticking and loss of brain responsiveness in sheep kept under experimental conditions. Averaged visual evoked electrocortical responses were used to assess brain responsiveness, and this technique is also being used to evaluate the duration of anaesthesia following electrical stunning.

METHODS

Stunning-to-sticking interval.

The interval between the start of stunning and the first appearance of blood from the sticking wound was measured in 10,129 sheep at 33 abattoirs. Measurements were made on 76% (± 19 SD) of a complete days kill at each abattoir. Fifteen % of the abattoirs used captive bolt stunning, 67% used low voltage - low frequency electrical stunning (93 V ± 21 SD; 50 Hz), and 18% used low voltage - high frequency stunning (133 V ± 14 SD; 1542 Hz ± 102 SD). These voltage measurements were made across a 159 ohm load.

The interval between sticking and loss of brain responsiveness.

Eighteen ewes were anaesthetised and ventilated with a 3:1 ratio of N_2O: O_2 plus halothane. Five mm diameter, bipolar, Ag-AgCl electrodes, which had been screened down to the recording surfaces with Araldite, were implanted onto the dura mater of the brain via holes drilled through the skull. The negative electrode was situated under the parietal bone, the positive electrode over the frontal cortex, and the earth electrode below the bregma. Electrocortical activity was monitored with an Elema Schonander recorder (700 Hz filter, 0.15 sec time constant) and stored on magnetic tape using a frequency-modulated recorder (Racal Store 7 DS).

Electrocortical responses were evoked using a flashing light (Grass Photic Stimulator, 2 flashes per sec). The light source was situated 1 m in front of the animal's eye, which were held open with eyelid retractors. Visually evoked responses were recorded before, during and for 3 min after percutaneous severance of both common carotid arteries, vagi nerves, external jugular veins, and the oesophagus and trachea, whilst the animal was under halothane anaesthesia.

The evoked responses which had been stored on tape were subsequently averaged with a Neurolog NL 750 averager, using a 250 msec sweep duration.

Effect of anaesthesia on evoked cortical responses.

Electrode placement and instrumentation were the same as those described in the previous subsection, except that the frequency of the flashlights was randomised between 1.0 and 1.5 flashes per sec, and the sweep duration of the averager was 500 msec. After implanting the electrodes, the sheep was allowed to recover from halothane anaesthesia whilst subjected to the flashing light. Thus, the effect of gradual resumption of consciousness on the evoked potentials was recorded.

Twenty two hours later the animal was stunned electrically with 100 V, 50 Hz, for 2.5 sec using dry electrodes placed over each temporal muscle. Evoked responses were recorded before and for 8 min after stunning. At the end of this period the animal was slaughtered in a conventional manner.

RESULTS AND DISCUSSION

Stunning-to-sticking interval.

Using the averages for each slaughterhouse, the mean stunning-to-sticking interval was 29 sec (± 15 SD). The range in stunning-to-sticking interval across the slaughterhouses was 5 to 82 sec, and the average stunning-to-sticking interval for all the sheep was 22 sec (± 12 SD). These estimates do not include animals which were stunned more than once on account of their apparent recovery from the previous stunning, when this was due to an interuption in the slaughter line.

The interval between sticking and loss of brain responsiveness.

Most studies on the loss of brain function following sticking have relied on the detection of a 'flat' or 'silent' electrocorticogram (ECoG), and this has been assumed to indicate a loss of brain responsiveness. In this study, evoked responses were used as they give an actual measure of brain responsiveness to a given stimulus. In addition, the responses were averaged, so as to eliminate electrocortical activity which was not synchronised with the flashing light. For humanitarian reasons, the experiment was performed on sheep which were kept under halothane anaesthesia, and this also helped to reduce interference in the ECoG from respiratory and other spasms associated with muscular activity.

Fig. 1. Averaged visually evoked potentails in a sheep anaesthetised with halothane. V.E.P.s were averaged from 3 consecutive groups of 255 flashes.

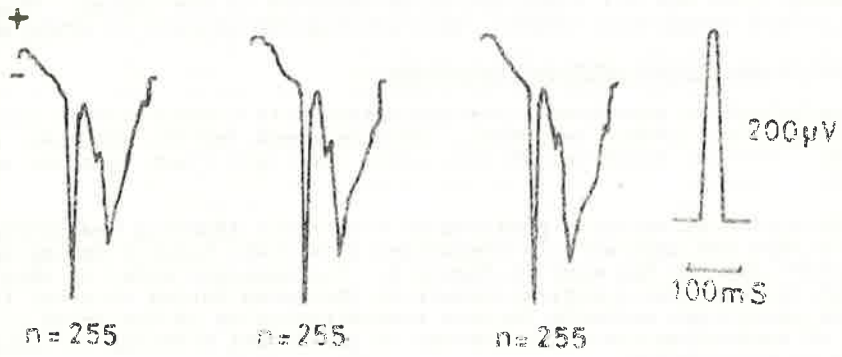
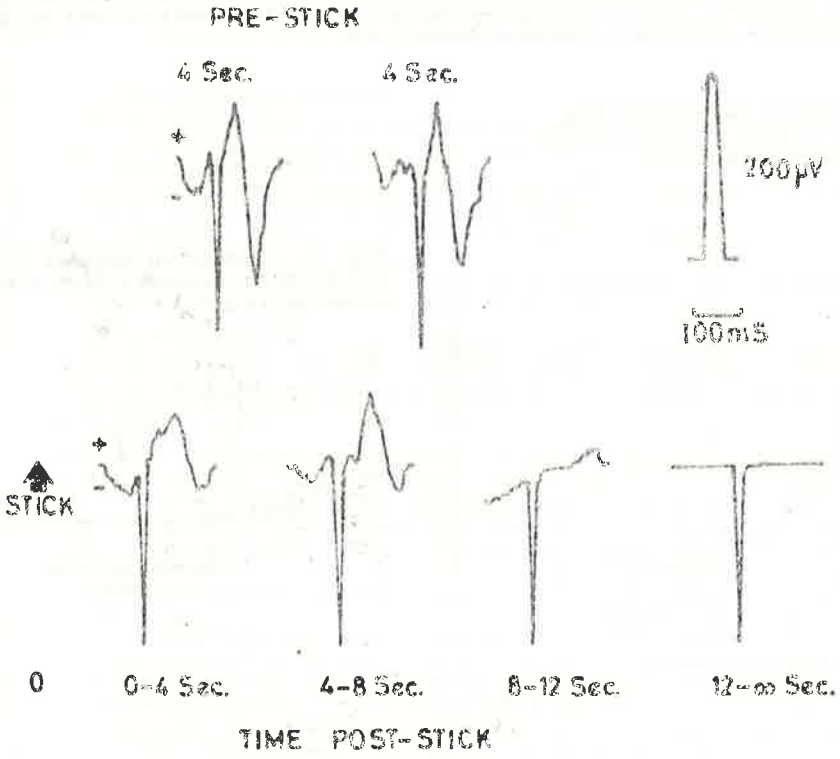


Fig. 2. V.E.P.s before and after sticking in sheep.



An example of the averaged visually evoked potentials (VEPs) in the anaesthetised state is shown in Figure 1. The first negative-going spike in each trace is a marker for the light flash, and the subsequent response was a predominantly negative potential of approximately 180 μV. The pattern of the response varies between individual sheep, but it was reproducible in the same animal for a given level of anaesthesia. Figure 2 shows the VEPs before and after sticking a sheep, and here again the first negative-going spike is the flash marker. Each trace is an average of eight responses, but when the interval between sticking and loss of brain responsiveness was measured, this was reduced further to averages of two consecutive responses (which equalled a time period of 1 sec). The scale of the potentials (and the time scale) shown in Figure 2 have been reduced from the original traces, where they equalled 13 μV/cm (and 25 msec/cm). Sticking resulted in a gradual reduction in the size of the evoked potentials, and for the sheep shown in Figure 2, complete loss of responsiveness occurred at 10½ sec.

Complete loss of responsiveness for the eighteen sheep occurred on average at 14 sec (± 4 SD) after sticking, and this interval varied between 9 and 25 sec. The displacement of the averaged responses at this time was 11 μV (± 2 SE) before the pair of flashes and 11 μV (± 1 SE) after the flashes. These estimates include DC drift, thermal noise from the transistors of the preamplifier and all other artifacts inherent in the system. They indicate that the VEPs did not exceed background 'noise', thus proving the absence of brain responsiveness.

Effect of anaesthesia on evoked cortical responses.

Recovery from halothane anaesthesia was associated with a reduction in the latency of particular potentials of the evoked responses. This is shown for the N_{35} wave, which represents the negative-going potential occurring 35 msec after the light flash when the animal was conscious (Figure 3).

When the electroplectic activity produced by electrical stunning had subsided, the latency of particular VEPs was increased in comparison with their latency during the conscious state. This is shown for the P_{29} wave in Figure 4. The apparent delay in this potential gradually returned to normal in a similar manner to that seen during recovery from halothane anaesthesia. This phenomenon warrants further investigation as it may prove to be a useful objective method of evaluating the effectiveness of electrical stunning in inducing a state which corresponds to anaesthesia.

CONCLUSIONS

On average the stunning-to-sticking interval was 22 sec, and the interval between sticking and loss of brain responsiveness was 14 sec. Thus, the required length of anaesthesia following stunning was estimated to be 36 sec. This figure, however, is based on averages, and further data are required before an estimate can be given for the worst part of the population as a whole. Once this estimate has been produced, we need to know which stunning techniques produce the required duration of anaesthesia. Evoked potentials may be an appropriate method for comparing the different stunning techniques.

Fig. 3. Change in latency of N_{35} wave of V.E.P.s with recovery from halothane anaesthesia (n=4)

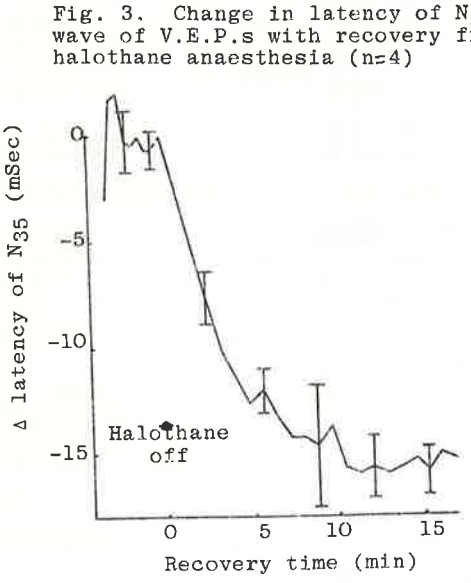


Fig. 4. Change in latency of P29 wave of V.E.P. with recovery from electrical stunning (n = 3).