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Time to collapse following slaughter without stunning in cattle

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ABSTRACT

Time to physical collapse was examined in 174 cattle which were restrained in the upright position and then released immediately from the restraint following the halal cut. The frequencies of swelling and false aneurysm in the cephalic and cardiac severed ends of the arteries were recorded. Fourteen percent of the cattle collapsed and stood up again before finally collapsing. The average time to final collapse for all the cattle was 20 s (sd ± 33). In 8% of the animals time to final collapse was ⩾60 s. Seventy-one percent of the cattle that took more than 75 s to collapse had false aneurysms in the cardiac ends of the severed carotid arteries. The frequency of swelling at the cephalic severed ends of the carotid arteries in 129 cattle was 7%. Failure to collapse within 60 s was associated with swelling of the cephalic ends of the carotid arteries.

1. Introduction

Shechita and halal slaughter are recognised by the Jewish and Muslim faiths as the appropriate methods for killing animals for meat consumption. The prescribed methods are based on tradition and date back to the respective divine direct methods. Outside those faiths, slaughter without stunning is recognised as a religious prerogative, but there have been concerns that the methods can compromise the welfare of the animals (FAWC, 1984). One of those concerns is about the rate at which the animals lose consciousness as this influences the length of time the animal could experience pain and/or distress following the cut.

There is uncertainty amongst scientists about how long it takes cattle to lose consciousness during slaughter without stunning. Studies which have examined either the time to brain failure using the electroencephalogram (EEG) or behaviour of the animal have produced conflicting results. In some studies calves lost brain function promptly, as assessed from spontaneous or evoked activity in the EEG or electrocorticogram (ECoG), and there was little variation between individual animals (Gregory & Wotton, 1984; Nangeroni & Kennett, 1963; Schulze, Schultze-Petzold, Hazem, & Gross, 1978). Whereas, other studies showed that some animals can take a relatively long time to either collapse or develop changes in spontaneous or evoked activity of their EEG or ECoG (Bager et al., 1992; Blackmore, 1984; Daly, Kallweit, & Ellendorf, 1988; Newhook & Blackmore, 1982).

During the course of a study into blood aspiration during slaughter without stunning, a cattle abattoir was identified where the standing animals were released from a head yoke as soon as the halal cut was made (Gregory, von Wenzlawowicz, & von Holleben, 2009). This abattoir was re-visited in the present study to determine the time to collapse following the cut. Time to collapse can be a useful indicator of the early stages of loss of consciousness. In other contexts, collapse or recumbency during the induction of cerebral hypoxaemia, hypercapnia or anaesthesia have been used as indicators of the early signs of loss of consciousness in humans and animals (Flecknell, 2000; Lambooij et al., 1999; Rossen, Kabat, & Anderson, 1943; Velarde et al., 2007).

2. Materials and methods

Halal slaughter without stunning was observed during four days kill at an abattoir in Belgium. One hundred and seventy-four cattle were held individually in a slaughter pen and head-locked in an upright position with a head yoke plus chin lift. The cut was made upwards across the neck from the animal's right hand side by a skilled halal slaughterman, usually with three cuts, where one cut represented a movement of the blade in one direction. As soon as the cuts had been made, the head and neck were released and the animal was allowed to bleed whilst standing unrestrained in the slaughter pen. The interval between the cut and the time the animal was no longer standing on four feet was recorded as the time to collapse. If an animal collapsed and subsequently got up again, the times to first collapse and final collapse were recorded separately.

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Swelling of the carotid arteries was recorded for both the cephalic and cardiac severed ends using the method of Gregory, Shaw, Whitford, and Patterson-Kane (2006). This method uses a 0–5 point scale where increasing number corresponds to increasing diameter of the swollen end of the artery. In the text of this paper, enlargement of the cephalic and cardiac artery ends are called 'swelling' and 'aneurysm', respectively. This distinction has been made because the nature of the enlargement has not yet been established for the cephalic end, whereas it is recognised that enlargement at the cardiac end is due to a false aneurysm (Gregory et al., 2006).

Linear regression and Fisher Exact Test were used in the statistical analyses.

3. Results

When the cattle were released from the head restraint, most stepped backwards, stood for varying lengths of time, swayed or became unsteady and then either fell to one side and slid down the wall or their hind limbs buckled and they fell backwards followed by loss of support from the forelimbs. When down, some animals sat in sternal recumbency, but most fell into lateral recumbency or were leaning laterally. Twenty-five cattle (14%) collapsed and returned to a four legged stance before collapsing again. Their initial collapse occurred on average at 29 ± 11 s ± se after the cut, and on average it was 20 s before the final collapse which occurred at 49 s after the cut.

The frequency distribution of the time to final collapse for all the cattle is shown in Fig. 1. It indicates that there was a skew in the distribution, with some animals taking a relatively long time to collapse. Fourteen animals (8%) took 60 s or more to achieve their final collapse, one of which had incompletely severed carotid arteries. The average time to final collapse was 19.5 s (median 11 s, maximum 265 s). An iterative curve fitting procedure for the descending slope of Fig. 1 indicated that the intercept in time to final collapse that corresponded to the best fit was 34 s ($y = 96.30 - 2.84x$; $r = -0.98$, $p < 0.05$, when using 10 s epochs for constructing the curve). Ninety percent of the cattle collapsed within this time period.

Size of false aneurysms in the cardiac ends of the severed carotid arteries was recorded in 136 cattle which also had data recorded for time to final collapse. Of these, one animal had incompletely severed carotid arteries. There was an association between late collapse following the cut and the presence of large aneurysms in the cardiac ends of the severed carotid arteries. Seventy-one percent of the seven cattle that took longer than 75 s to collapse had a cardiac severed artery end with an aneurysm score of $\geqslant 3$. Whereas, only 25% of the cattle that collapsed within 75 s of the cut had a cardiac artery end with an aneurysm score of $\geqslant 3$ ($p < 0.05$).

One hundred and twenty-nine cattle were scored for swelling of the cephalic ends of the severed carotid arteries. Nine of them (7%) had at least one cephalic end that was swollen to more than 1 cm in diameter, and one animal had a swelling that was at least 2 cm in diameter. One animal had swelling in the cephalic ends of both severed carotid arteries. There was an association between the frequency of animals that took a long time to collapse ($\geqslant 60$ s) and swelling of the severed cephalic end of the arteries. A higher proportion of the cattle that took at least 60 s to collapse had swelling in the cephalic ends of the severed carotid arteries ($p < 0.05$; Table 1).

All the cattle that had no false aneurysms or swellings in any of the four severed ends of the carotid arteries (aneurysm/swelling score = 0; $n = 37$) collapsed within 34 s of the cut, whereas 14% of the cattle with a cumulative false aneurysm and swelling score of 1 or more took longer than 34 s to collapse ($p < 0.05$).

The hot carcass weight of the cattle varied between 285 and 600 kg (mean 418 ± 74 kg ± sd).

4. Discussion

Fourteen percent of the cattle collapsed and subsequently raised themselves to stand on all four feet before collapsing again. The interval between the first and final collapses was on average 20 s. This brief recovery in behaviour has not been noted before because cattle are usually restrained during the main part of the bleeding period following slaughter without stunning. However, Newhook and Blackmore (1982) suggested that resurgences of consciousness appear to occur following slaughter without stunning, based on the amplitude and rhythm of the spontaneous EEG. In addition, Hoffman (1900) observed loss and subsequent return of the corneal reflex in an unspecified number of cattle during shechita. One explanation for these effects is as follows. The induction of insensibility, and the recovery from insensibility, can be

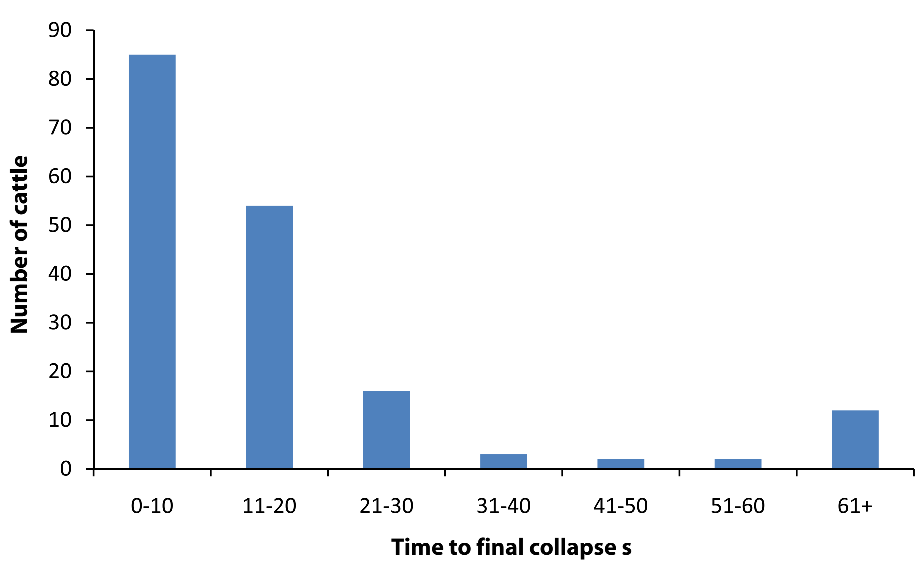

Fig. 1. Frequency distribution of the cattle according to time to collapse following halal slaughter without stunning.

Table 1
Frequency of delayed time to collapse following slaughter without stunning in relation to the frequency of swelling in the cephalic ends of the carotid arteries.

Time to collapse following the cut s	Swelling in the cephalic severed ends of the carotid arteries	
	Absent (%)	Present (%)
<60	115 (96%)	4 (44%)
⩾60	5 (4%)	5 (56%)

phasic (Gregory & Shaw, 2000). In other words, subjects can repeatedly drift in and out of consciousness as they regain or lose overall consciousness. This can occur, for example, when humans wake up from sleep or recover from head injury. In the case of loss of consciousness during haemorrhage, the escape of blood can occur in two phases (Gregory, 2005). There can be a spontaneous second haemorrhagic spurt after the initial rapid flow of blood (Milles, Koucky, & Zacheis, 1966). This resurgence in flow is thought to be due to splenic contraction and secondary vasoconstriction. In primates, these second haemorrhages have been associated with transient blood pressure rises and with a resurgence of consciousness (Bar-Joseph, Safar, Stezoski, Alexander, & Levine, 1989). It is possible that the 14% of cattle in this study that collapsed more than once following the halal cut were showing this phasic effect. In conclusion, the recovery of a standing position confirms that the first collapse did not signify total loss of consciousness in all animals, but implies that it was a good indicator of the start of insensibility at a superficial plane. In 14% of the cattle there was a phasic return of sensibility lasting on average for 20 s.

An important finding from this study was that 8% of the cattle experienced a delay of 60 s or more between severing both carotid arteries and final physical collapse. Long durations between completing the cut and the onset of unconsciousness are associated with a higher risk of pain or distress, as this period is associated with nociceptive neural activity in the brain (Gibson et al., 2009). Ten percent of all the cattle failed to collapse within 34 s, which was assumed from an analysis of the frequency distribution of the time to final collapse to be the upper limit of normality.

The finding that there is a delay of ⩾60 s in time to loss of consciousness in about 8% of cattle might explain why there have been different conclusions on time to brain dysfunction in previous studies. Previous experimental work has been based on calves and there have been insufficient animals to allow for this relatively low frequency of extended consciousness (e.g. Gregory & Wotton, 1984; Shaw, Bager, & Devine, 1990).

The reason for prolonged consciousness in some cattle is thought to be due to occlusion of the severed cardiac ends of the carotid arteries in association with continued perfusion of the brain through the basi-occipital plexus. Prolonged consciousness was associated with aneurysm formation in the cardiac ends of the severed arteries. Seventy-one percent of the cattle which took longer than 75 s to collapse had a cardiac end aneurysm that was at least 3 cm in diameter. This suggests that cardiac end aneurysms might contribute to extreme cases of prolonged consciousness following the cut. There was also an association between swelling of the cephalic severed end and late collapse. An altered pressure gradient after ventral neck incision causes blood in the vertebral arteries to be directed away from cerebral blood circulation and out through the cephalic ends of the carotid arteries (Bager, Devine, & Gilbert, 1988; Baldwin, 1971). If blood flow is impeded from this cephalic end, pressure may build up and increase blood flow through the rete mirabilis and maintain cerebral circulation for longer. It was not established whether the swellings in the cephalic severed ends were platelet (white) clots, normal red clots or false aneurysms, but this distinction may not be important as blood would have to be flowing via the vertebral artery and through the cephalic severed end of the carotid artery to produce each type of occlusion. In 56% (5 out of 9) of the cases where cephalic end swelling occurred, there was a delay in loss of consciousness. Considering that the occipito-vertebral anastomosis is a minor tributary compared with the basi-occipital plexus (Baldwin, 1960), this implies that occlusion and swelling of the cephalic severed ends of the carotids could contribute to protracted cephalic perfusion and potential for sustained consciousness. It is also relevant to note that, in calves that are electrically stunned and then stuck, protracted flow from the severed jugular veins can be a sign of continued cephalic perfusion (Bager et al., 1988).

In conclusion, this study has produced four important findings. Firstly, it provides a more reliable estimate of the range in duration of consciousness in cattle following slaughter without stunning than has been achieved hitherto. Secondly, it provides an estimate of the proportion of cattle that experience a prolonged period of consciousness following a skilled halal cut. Thirdly, it showed that a proportion of cattle (14%) collapsed and stood up again, and it is likely that these animals were distressed. Lastly, it strengthens the evidence that carotid aneurysms are at least partly responsible for prolonged consciousness in cattle following the halal cut. In this respect it will provide an incentive for religious slaughter authorities to manage the problem of protracted consciousness in cattle, and it will help direct future work which will need to examine ways of minimising the frequency of prolonged consciousness.

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