

## Comparison of Halal slaughter with captive bolt stunning and neck cutting in cattle: exsanguination and quality parameters

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### Abstract

Some supporters of religious slaughter methods claim that efficiency of bleed-out is adversely affected by stunning. Our previous study carried out in sheep at an abattoir comparing the Muslim method of slaughter without stunning with pre-slaughter stunning using a captive bolt or by electrical methods concluded that bleed-out is not adversely affected by stunning, nor improved by a neck cut without stunning. In this paper, a similar study carried out in cattle is reported. In this study, captive bolt stunning followed by neck cutting was compared with the Muslim slaughter method without stunning. The total blood loss, percentage blood loss expressed as a percentage of live weight and percentage loss of estimated total blood were calculated and compared between each group. In addition, the time periods taken to reach 25, 50, 75 and 90% of total blood loss were also calculated. There was no significant difference between the two stunning groups for any of these blood loss variables. The results, subjected to statistical analyses, also showed no apparent difference in the PCV levels and meat quality parameters between treatments. These results confirm the findings with sheep and show that the bleed-out is not adversely affected by captive bolt stunning, nor improved by a neck cut without stunning in cattle. It is anticipated that these findings may help promote the use of stunning methods during Halal slaughter.

**Keywords:** animal welfare, blood loss, Halal slaughter, stunning

### Introduction

The slaughter of animals without stunning, on grounds of religion, is permitted in UK Law, through the Welfare of Animals (Slaughter and Killing) Regulations 1995 (Ministry of Agriculture Fisheries and Food [MAFF] 1995). Religious slaughter by the Jewish (Shechita) or the Muslim (Halal) methods is also permissible in parts of Europe and in certain Western nations. However, while some European countries have banned slaughter without stunning, others continue to debate this controversial issue. There are a number of welfare issues relating to pre-slaughter handling (Dunn 1990; Anil *et al* 1993; Grandin 1987, 1994) most notably, pain and distress during the neck cut and the duration of sensibility in the period after slaughter prior to loss of brain function (Daly *et al* 1988; Kalweit *et al* 1989; Anil *et al* 1995a). The Farm Animal Welfare Council (FAWC), having considered these issues, concluded that religious slaughter without stunning would compromise animal welfare. On this basis, the FAWC recommended that exemption from stunning should be repealed on the strength of welfare concerns. One of the most keenly debated issues relates to the efficiency of bleed-out, which is claimed, by those who support religious slaughter, to be better when stunning is not used. An effective bleed-out is a prerequisite for both Jewish (Shechita) and Muslim (Halal) slaughter methods.

Some promoters and defenders of religious slaughter methods maintain that blood loss can be impeded, due to neurological, muscular and cardiovascular changes, when stunning methods are applied. Some of the reasons for this claim originate from biblical laws and the Koran (Masri 1989) that prohibit the consumption of blood. Although stunning, with the exception of killing before exsanguination, is deemed acceptable by a considerable proportion of Muslims, Jewish authorities have other religious arguments and reject stunning.

A number of studies have tried to address this issue in the past without reaching any firm conclusions, although there are reports of more efficient exsanguination after Shechita compared to using a bolt (Levinger 1976, 1995). Kalweit *et al* (1989) did not note any differences in the relative level of haemoglobin in different muscles in the aftermath of captive bolt stunning and Shechita in sheep and calves. Similarly, the method of slaughter made no difference to the amount of blood lost after neck cutting in broilers, and there was no difference in the amount of retained blood in different cuts (Kotula & Helbacka 1966). Griffiths *et al* (1985) found higher haemoglobin content in broilers after Halal slaughter that they attributed to excessive convulsions. We have recently reported the findings of a comparative study carried out in sheep at an abattoir used for

Muslim method of slaughter (Anil *et al* 2004). The aim of this study was to demonstrate whether pre-slaughter stunning with either a captive bolt or by electrical methods adversely affected exsanguination compared with the neck cut method without stunning. The conclusion reached was that the bleed-out is not adversely affected by electrical and captive bolt stunning, nor is it improved by a neck cut without stunning in sheep. However, it was unclear whether these findings could be applied to slaughter cattle as certain key anatomical differences exist between sheep and cattle; most notably concerning the blood supply to the head. It has been shown that cerebral circulation can be influenced by the additional extravascular branches in the neck of cattle (Baldwin & Bell 1963b,c). Therefore another study, similar to the recently published sheep investigation (Anil *et al* 2004), was performed and is reported in this paper.

### Materials and methods

A total of 26 slaughter cattle weighing 290–436 kg were used at a commercial slaughterhouse in Istanbul. These animals were all intended for slaughter by the Muslim method which would entail no pre-slaughter stunning. For the purposes of the study, captive bolt stunning was included as a treatment once permission from the abattoir had been obtained. The animals were randomly assigned to one of the following treatment groups:

Group 1 — Slaughter by neck cutting only. These animals were restrained by the slaughterman, who used a shackle applied to one of the hindlegs, before performing the traditional Muslim slaughter method and severing all the vessels in the animals' neck with one cut ( $n = 13$ ) immediately after hoisting the animal.

Group 2 — Captive bolt stunning (Cash Special, manufactured by Accles and Shelvoke, Sutton Coldfield, West Midlands, UK) followed by hoisting and sticking as in Group 1 within 30 seconds ( $n = 13$ ).

The animals arrived at the abattoir during the morning and were rested in the lairage for approximately 1 hour before being slaughtered. Each animal was weighed before being taken to the slaughter pen where it was assigned to one of the treatment groups. Captive bolt stunning and/or slaughter by neck cutting was carried out whilst the animal was restrained by a shackle applied around one of the hind legs. The same shackle was used for hoisting the animal immediately before neck cutting/sticking.

The neck cutting, with or without captive bolt stunning, was carried out immediately after the hoisting. Prior to neck cutting, a large plastic bin was positioned below the head of each animal. The bin was placed on top of a digital display balance on the floor and collected the blood from the sticking wound. To ensure that the amount of blood loss could be monitored during the entirety of the slaughter process, the digital display on the balance was videotaped. Blood collection lasted for 2 minutes following sticking to allow sufficient time for complete bleed-out prior to the commencement of cattle carcass dressing.

During sticking a 10 ml blood sample was collected into anti-coagulated tubes. From this sample packed cell volume (PCV) measurements were made. The remaining blood was centrifuged, plasma collected and stored for future investigations.

On completion of the 2 minute bleed-out the total amount of blood collected was recorded. The carcass was then dressed and eviscerated. After evisceration, internal organs, hide and dressed carcass were weighed and recorded.

A pH measurement was taken from the neck muscles on the carcass at 45 minutes post-sticking. In addition, a sample of (*M. trapezius*) muscle was taken for pH and colour assessment the following day. The meat sample was stored in a refrigerator overnight. At 24 hours post-sticking the second pH measurement was made. The sample was then cut into two pieces, and placed onto a plastic tray with the two cut surfaces facing up. The samples were then covered with cellophane and allowed to stand for one hour. After one hour the meat was subjectively scored for colour by comparing the lightness and/or darkness of each meat sample with a graduated set of coloured photograph standards used at Bristol University, UK (see Anil *et al* 2004). The scale ranged from 1 to 6, with 1 indicating the lightest and 6 the darkest. Colour was determined to see the effects of stunning and slaughter treatments on meat quality.

The video recordings of the blood loss and weight measurements from each animal were subsequently analysed. The blood collected every 10 seconds from the start of sticking was measured. Blood loss was expressed as a percentage of live weight and the percentage loss of estimated total blood was also calculated. In addition, the time taken to reach 25, 50, 75 and 90% of total blood loss were also calculated. It is possible to calculate the estimated total blood weight of an individual animal by using the following equation:

#### Estimated total blood weight (kg)

$$\frac{\text{volume (ml)} \times \text{specific gravity}}{1000}$$

Whereby the volume of blood can be determined by 57 ml kg<sup>-1</sup> body weight and specific gravity of cattle blood is 1.052.

From here the estimated percentage blood loss for each animal was calculated using the equation:

#### Loss of estimated total blood weight(%)

$$\frac{\text{Total Blood Loss} \times 100}{\text{Estimated Total Blood Weight}}$$

In addition, blood loss was also expressed as a percentage of live weight by using the following equation:

**Table 1** Comparison of variable measurements made on cattle following different slaughter methods.

Variable	No stunning mean $\pm$ SE	Captive bolt stunning mean $\pm$ SE	Assuming equal variances <sup>©</sup>	t	df	Significance
Live weight (kg)	363.5 $\pm$ 5.7	355.3 $\pm$ 12.2	No	0.61	16	ns
Carcass weight (kg)	194.8 $\pm$ 3.2	188.0 $\pm$ 6.7	No	0.93	17	ns
Hide weight (kg)	31.23 $\pm$ 0.83	31.54 $\pm$ 0.97	Yes	-0.24	24	ns
Organ weight (kg)	11.57 $\pm$ 0.26	11.68 $\pm$ 0.30	Yes	-0.27	24	ns
PCV (%)	40.9 $\pm$ 0.90	40.0 $\pm$ 1.39	Yes	0.56	24	ns
pH (45 min)	7.01 $\pm$ 0.03	7.06 $\pm$ 0.03	Yes	-1.08	24	ns
pH (24 h)	6.17 $\pm$ 0.04	6.20 $\pm$ 0.05	Yes	-0.44	24	ns
Colour	4.91 $\pm$ 0.12	4.80 $\pm$ 0.17	Yes	0.55	24	ns

df — degrees of freedom; Significance — level of significance

ns — Not significant at the 0.05 level of significance

<sup>©</sup> — *F*-test two-sample for variances carried out to determine which *t*-test to use**Table 2** Table of means from two-sample *t*-tests.

Variable	No stunning mean $\pm$ SE	Captive bolt stunning mean $\pm$ SE	Assuming equal variances <sup>©</sup>	t	df	Significance
Total blood loss(kg)	10.85 $\pm$ 0.35	10.89 $\pm$ 0.69	No	-0.05	16	ns
Live weight (kg)	363.5 $\pm$ 5.63	355.3 $\pm$ 12.34	No	0.61	16	ns
Estimated total blood weight(kg)	21.80 $\pm$ 0.34	21.31 $\pm$ 0.74	No	0.61	16	ns
Estimated % blood loss	49.92 $\pm$ 1.63	51.70 $\pm$ 3.49	No	-0.46	16	ns
Blood loss as a % of live weight	2.99 $\pm$ 0.1	3.10 $\pm$ 0.21	No	-0.46	16	ns

df — degrees of freedom; Significance — level of significance

ns — Not significant at the 0.05 level of significance

<sup>©</sup> — *F*-test two-sample for variances carried out to determine which *t*-test to use**Table 3** The average rate of blood loss in cattle following different slaughter methods.

	No stunning mean $\pm$ SE	Captive bolt stunning mean $\pm$ SE	Assuming equal variances <sup>©</sup>	t	df	Significance
Time to 25% blood loss (s)	17.3 $\pm$ 2.4	10.6 $\pm$ 1.5	Yes	2.29	13	*
Time to 50% blood loss (s)	37.5 $\pm$ 2.8	35.8 $\pm$ 3.7	Yes	0.36	18	ns
Time to 75% blood loss (s)	68.0 $\pm$ 4.5	67.6 $\pm$ 2.9	Yes	0.08	18	ns
Time to 90% blood loss (s)	94.4 $\pm$ 4.9	94.0 $\pm$ 2.0	No	0.08	11	ns

Percentages are of the blood loss at 120 s

df — degrees of freedom; Significance — level of significance

\*  $P < 0.05$ ; ns — not significant<sup>©</sup> *F*-test two-sample for variances carried out to determine which *t*-test to use

NB There were missing values in this data: times were not recorded for all 13 animals in each group. For example, for 25% blood loss times were recorded for 8 animals (no stunning) and 7 animals (captive bolt stunning).

**Blood Loss as a percentage of Live Weight**

$$\frac{\text{Total Blood Loss} \times 100}{\text{Live Weight}}$$

Live Weight

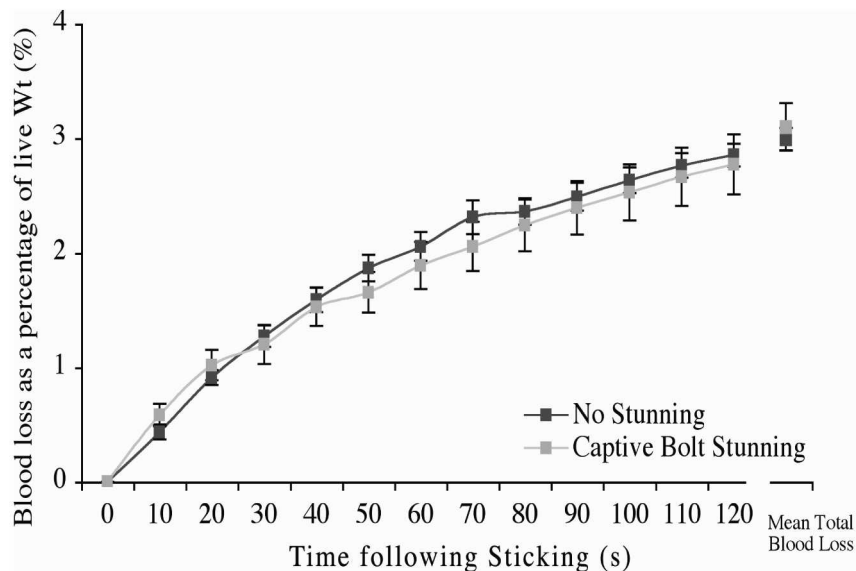
All results were subjected to statistical analyses. The variables were analysed using the appropriate independent two-sample *t*-test. An *F*-test two-sample for variances was performed beforehand to determine which *t*-test to use. If the *F*-test was not significant a two-sample *t*-test assuming

equal variances could be used. If the *F*-test was significant then it was necessary to use a *t*-test two-sample assuming unequal variances. The software packages used were Minitab (Release 14) and SPSS (Version 12.0).

**Results**

In order to determine whether there were possible differences between the animals in the two groups that might affect measured blood loss data, the carcass, hide, fleece and organ weights as well as the PCV, pH and colour measurements were compared statistically. Results reveal no

Figure 1



Blood loss as a percentage of live weight following slaughtering by different methods in cattle (Mean  $\pm$  SE).

significant differences (at the 0.05 level of significance) between the carcass measurements for the animals allocated to each stunning group. The mean live weight of the animals in the no-stunning group was 363 kg, compared to 355 kg for the stunning group (captive bolt). However, the difference between these weights was not significant.

The blood loss variables in Table 2 were analysed using the appropriate two-sample *t*-test as indicated. There was no significant difference between the two stunning groups for the actual blood loss in kg. It was estimated that the mean total blood weight for the animals in the no-stunning group was slightly higher at 21.8 kg than the estimated mean of 21.3 kg of blood for the captive bolt group with the slightly lower mean carcass weight; these differences were not significant.

Table 2 shows that on average the animals subjected to captive bolt stunning lost an estimated 51.7% of their blood, this compares to the 49.9% estimated blood loss for animals that were not stunned. There was no significant difference between the means for the two groups. From Table 2 and Figure 1 it can be deduced that the unstunned animals lost 2.99% of their live weight during exsanguination. Whereas, the animals subjected to captive bolt stunning lost 3.1% of their live weight during sticking. Again these differences were not significant.

Figure 1 shows the mean rate of blood loss, expressed as a percentage of live weight following different slaughter methods. The graph indicates some slight variations in rate through time but the final percentage losses after 2 minutes were not found to be significantly different.

Another way of interpreting the blood loss was to examine the rate at which the blood was collected following sticking (Table 3). In particular the time taken to reach 25, 50, 75 and

90% of the total blood loss collected during the 120 second bleed-out period was compared for each group.

The animals that were not stunned took significantly longer (17.3 seconds) to bleed out 25% of their total blood loss compared to the stunned group (10.6 seconds). However, by the time the animals had bled out to 50, 75 and 90% of their total blood loss these differences were no longer significant.

These results showed that captive bolt stunning followed by a neck cut did not impede exsanguination in terms of the rate of blood loss and total blood loss when compared with Halal slaughter without stunning. In addition, meat quality parameters determined as pH, PCV and colour were not affected (see Table 1).

## Discussion

Religious slaughter, remains a controversial issue among the general public, religious communities, veterinarians, national and European government offices and welfare organisations, and is still being debated at different levels within Europe. One of the main points of contention is whether or not to allow slaughter without pre-slaughter stunning. While some countries have banned religious slaughter without stunning (eg Norway and Sweden), others either allow the flexible practice (eg UK) or have introduced new angles of debate and legal arguments (eg Germany). Muslim rules for Halal meat state that, although blood has to first flow out of the live animal, residual blood that remains in the meat is not as prohibitive (Quran 6:145, see Masri [1989]). In addition to the specific requirements relating to the selection, fitness and treatment of animals and the slaughter method, both Jewish and Muslim religions require an effective maximum bleed-out. One of the major requirements is that blood, either in exsanguinated form or in the meat, must not be consumed. There are references to slaughter rules and prohibition of consumption of blood in



the holy books (Talmud; see Levinger [1995], Quran 6:145; see Masri [1989]). The main objection to stunning methods concern the claim that it prevents all of the blood draining from the animal and the carcass.

The previous study in sheep has shown no difference in the bleed-outs between slaughter after stunning and neck cutting without stunning (Anil *et al* 2004). However, these results may not have been applicable in cattle due to the anatomical differences with sheep. In cattle the cranial blood supply can be modified by additional vascular branches that affect cerebral circulation (Baldwin 1960; Baldwin & Bell 1963a,b,c). It has been known that cattle often have a prolonged duration of sensibility after stunning (Blackmore 1984; Bager *et al* 1992) and slaughter (Gregory & Wotton 1984; Anil *et al* 1995a). Studies have shown that following an optimum cut, the time to loss of brain responsiveness can be as low as 17 seconds in slaughter calves (Gregory & Wotton 1984) whereas, if occlusions occur this interval can be as long as 120 seconds (Anil *et al* 1995b). In spite of these intra-species differences, these results seem to suggest no scientific basis for claims that stunning impedes blood loss. Therefore, the concerns of some members of the Islamic community about the use of pre-slaughter stunning methods should be alleviated by these findings.

Pre-slaughter stunning is already in use for some, if not all, Halal slaughtering in most European countries. As far as Muslim slaughter is concerned pre-slaughter stunning that does not stop the heart before the start of exsanguination should be acceptable and encouraged (Rosen 2004). Therefore, captive bolt and head-only electrical stunning methods are suitable; whereas cardiac arrest electrical stunning (head-to-back) and gas stunning that kill the animal before commencement of exsanguinations would be excluded. This report has responded to claims of bleed-out differences, and it is hoped, may help extend the use of stunning methods prior to Halal slaughter to countries such as Turkey. However, these findings may not be applicable to Shechita, the Jewish method, for various reasons. These include the different method of cutting with a specially designed, frequently sharpened knife (chalaf), and the requirement for no tissue damage prior to exsanguination (Rosen 2004). Nevertheless, from a scientific point of view, similar experiments, involving stunning versus no stunning effects on exsanguination, need to be repeated for Shechita before extrapolating these results to the Jewish method of slaughter. It may be likely that advocates and defenders of Shechita might refute these claims until such time as a similar scientific investigation that focused upon their own specific protocol was carried out. The proposed experiments would, at present, merely aim to answer the scientific question of whether or not Shechita can provide a better bleed-out. As the current stunning methods are claimed to cause varying degrees of tissue damage, Shechita operators are unlikely to accept existing pre-slaughter stunning methods.

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