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Comparison of religious slaughter of sheep with methods that include pre-slaughter stunning, and the lack of differences in exsanguination, packed cell volume and meat quality parameters

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Abstract

UK legislation requiring pre-slaughter stunning has certain exemptions for religious slaughter. Supporters of both Muslim (Halal) and Jewish (Shechita) slaughter methods claim that the efficiency of the bleed out is adversely affected by stunning. In this study, electrical stunning followed by neck cutting, and captive bolt stunning followed by neck cutting, were compared with the Muslim slaughter method (neck cutting without stunning) in sheep. Total blood loss and percentage blood loss, expressed as a percentage of live weight, were calculated and compared between groups. In addition, the time taken to reach 25%, 50%, 75% and 90% of total blood loss was calculated and compared. There was no apparent difference in the packed cell volume levels between groups. Slaughter method did, however, affect meat pH and colour. The results show that the bleed out after neck cutting is not adversely affected by electrical or captive bolt stunning; nor is an improved bleed out achieved by neck cutting without stunning.

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

Introduction

In the UK, the Welfare of Animals (Slaughter and Killing) Regulations 1995 (MAFF 1995) require all meat animals to be stunned prior to slaughter. However, there is an exemption in relation to religious slaughter, which remains a controversial issue. Most religious slaughter in Europe and Western countries, where allowed by law, is carried out by either the Jewish (Shechita) or the Muslim (Halal) method.

The Farm Animal Welfare Council (FAWC), in a series of discussions with interested parties including scientists and representatives of government, welfare and religious organisations, considered the welfare aspects of religious slaughter as practiced in the UK (FAWC 2003). FAWC concluded in its report that pre-slaughter handling (Dunn 1990; Grandin 1988, 1994) and induction to a period of unconsciousness can cause stress and present welfare problems if no stunning method is used (Daly *et al* 1988; Kalweit *et al* 1989; Anil *et al* 1995). On this basis, FAWC recommended that the exemption for religious slaughter be repealed. The following issues have frequently been considered and debated in relation to religious slaughter methods:

i) The possibility of undue stress during handling prior to slaughter (Grandin 1988, 1994; Dunn 1990).

ii) The possibility of the neck incision being painful during the cut and/or immediately afterwards.

iii) Whether sensibility is lost quickly enough following exsanguination ('sticking') (Daly *et al* 1988; Kalweit *et al* 1989; Anil *et al* 1995).

One of the issues often debated is whether bleed-out rates and total blood loss resulting from neck cutting without stunning are higher than those with stunning. Advocates of slaughter that precludes stunning claim that blood loss can be impeded by stunning, as a result of the neurological, muscular and cardiovascular changes caused by this practice. Some of the reasons for this claim originate from the Jewish biblical laws (Talmud; see Levinger [1995]) and the Quran (Masri 1989), both of which prohibit the consumption of blood. In order for meat to be acceptable (kosher) for Jews, blood must not be consumed either in exsanguinated form or in the meat. According to the Muslim rules for Halal meat, blood must first flow out of the live animal; residual blood that remains in the meat is not, however, prohibited (Quran 6:145, see Masri [1989]). However, both religions require an effective maximum bleed out. Although stunning is acceptable to many Muslims (but not killing before exsanguination), Jewish authorities that control Shechita have other religious arguments and, to our knowledge, all reject pre-slaughter stunning.

Numerous studies have been carried out in order to address this issue but have failed to reach any firm conclusions, although there are some reports of better exsanguination after the Shechita method of neck cutting without stunning than after neck cutting following captive bolt stunning (see Levinger 1976, 1995). However, Kalweit *et al* (1989) found no difference in the amount of haemoglobin in different muscles (indicating bleed-out completeness) in sheep and calves subjected to captive bolt stunning or the Shechita method. Similarly, the method of slaughter made no difference to the amount of blood loss after neck cutting in broilers, or to the amount of blood retained in different cuts (Kotula & Helbacka 1966). Griffiths *et al* (1985) found higher haemoglobin content in the muscles of broilers that had undergone the Muslim method of slaughter compared with methods involving pre-slaughter stunning, which they attributed to excessive convulsions during the Muslim method.

The aim of this investigation was to determine, in a comparative study of sheep at an abattoir used for the Muslim method of slaughter, whether pre-slaughter stunning with a captive bolt or by electrical methods adversely affected exsanguination compared with neck cutting without stunning.

Materials and methods

A total of 60 sheep, weighing 22–68 kg, were slaughtered at two commercial abattoirs in Istanbul, Turkey. They were intended for slaughter by the Muslim method with no pre-slaughter stunning, but for the purposes of this study two stunning methods were included in the treatments, with the permission of the abattoir management, giving a total of three treatment groups:

Group 1: Slaughter by neck cutting only. These animals were restrained by the slaughterman, who performed the Muslim slaughter method of severing all the vessels in the animal's neck with one cut (n = 30).

Group 2: Head-only electrical stunning using 350 V for 3 s by a Cash Electrical Stunning device (Accles and Shelvoke, UK). Following stunning the animals were hoisted and stuck within 30 s (n = 18).

Group 3: Captive bolt stunning by a Cash Special gun activated by a 3 grain cartridge. Following stunning the animals were hoisted and stuck within 30 s (n = 12).

The sheep arrived at the abattoirs during the morning and were rested in the lairage for approximately 1 h prior to slaughter. Each individual was removed from the pen and weighed before being taken to the slaughter area where it was assigned to a treatment group. At the first abattoir, 36 animals were randomly assigned to one of two treatment groups: not stunned, and electrically stunned. At the second abattoir, 24 animals were assigned to one of two treatment groups: not stunned, and stunned by captive bolt.

Immediately prior to sticking, each animal was positioned above a large plastic bin placed on top of a digital balance, and the blood was collected from the sticking wound. The display on the balance was continuously recorded by video recorder during the sticking process so that the amount of blood collected could be monitored. Blood collection lasted for 2 min following sticking, after which the total amount of blood collected was recorded from the balance display. This period was chosen in order to mimic the duration that sheep slaughtered in the UK spend on the bleed rail before carcass dressing. However, the bleed out was complete after 90 s in most carcasses. The video recordings of the blood measurements from each animal were subsequently analysed by measuring the amount of blood collected at 10 s intervals after sticking. In addition, the time taken to reach 25%, 50%, 75% and 90% of total blood loss was calculated.

During sticking, a 10 ml blood sample was collected into an anti-coagulation tube. From this sample, packed cell volume (PCV) measurements were made, as stress and sympathetic stimulation will increase PCV. The remaining blood from the sample was centrifuged, and the plasma collected and stored for future investigation. On completion of the 2 min bleed out, the carcass was dressed and eviscerated. During these processes the weights of the internal organs, hide, and dressed carcass were recorded.

At 45 min post-sticking, a pH measurement was taken from the neck muscles of the carcass. In addition, a sample of muscle (M. trapezius) was removed from the neck for subsequent pH and colour analysis and stored in a refrigerator overnight. At 24 h post-sticking, a pH measurement was made on this sample. It was then cut into two pieces and placed on a plastic tray with the two cut surfaces facing upwards. The samples were then covered with cellophane and allowed to stand for 1 h before being subjectively scored for colour by comparing the lightness or darkness of the meat to a set of graduated photographs of colour standards used at Bristol University, UK. The scale was 1–6, with 1 being the lightest and 6 being the darkest. This procedure was carried out in order to assess whether there was any effect of the stunning and slaughter treatments on the colour of the meat. It was not possible to use the same judges on each day.

Preliminary analyses for each abattoir separately indicated no significant differences between the means of the blood loss variables for the different treatment groups. Similarly, there was no significant difference between mean blood loss on the two different days at the two abattoirs for the no-stunning group. It was therefore decided to pool the data from both abattoirs. All carcass and percentage blood loss data were analysed by a one-way analysis of variance (ANOVA) with slaughter method as a factor. Pairwise comparisons were conducted using the least significant difference procedure *post hoc*. In addition, the covariate 'live weight' was added to the ANOVA for analyses involving the blood weights taken at 10 s intervals, in order to take into account the range of live weights when comparing blood loss. The software packages used were Minitab (Release 11) and SPSS (Version 11.5).

Results

Analysis revealed a significant difference between the live weights of the animals from different groups ($P < 0.05$) (Table 1). Sheep in the electrical stunning group were significantly heavier than those in the no-stunning group and in the captive bolt stunning group: half of the animals

Table 1 Comparison of blood, carcasses and meat variables after different slaughter methods.

Variable	No stunning	Electrical stunning	Captive bolt stunning	*df*	VR	SED	Significance
Live weight (kg)	38.6[a]	45.6[b]	37.5[a]	57	4.91	2.82	*
Fleece and hide weight (kg)	4.1	3.9	4.2	57	0.49	0.30	ns
Weight of viscera (kg)	1.8[b]	2.1[c]	1.4[a]	56	9.64	0.14	***
PCV (%)	36.4	36.6	35.7	31	0.21	1.53	ns
pH (45 min)	6.6[b]	6.4[a]	6.7[b]	57	7.57	0.08	***
pH (24 h)	5.7[b]	5.1[a]	6.2[c]	57	20.59	0.16	***
Colour	2.8[ab]	2.5[a]	3.1[b]	57	4.14	0.19	*
% Blood loss	3.98	3.78	4.22	54	0.80	0.318	ns

Values are the means from the ANOVA with slaughter method as a factor. Means in a row with the same superscript do not differ significantly. Means in a row with different superscripts differ significantly. % Blood loss is blood loss after 90 s as a percentage of live weight.
df = residual degrees of freedom
VR = variance ratio
SED = standard error of difference between means
ns = not significant
Significant at * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

in the no-stunning group and all of those in the electrical stunning group were heavier than those in the captive bolt stunning group. The reason for this difference was that sheep were slaughtered in groups over which we had no control of liveweights.

There was no significant difference between the fleece and hide weights of animals in different groups (Table 1). There were significant differences ($P < 0.001$) between the weights of the viscera (heart, lungs, liver and spleen) from animals in the different groups. Again, these differences resulted from some of the organs originating from heavier animals, rather than from the slaughter method applied.

The mean PCV values for the three treatments, determined in exsanguinated blood, were not significantly different. However, both pH variables were significantly different ($P < 0.001$) between groups. At 45 min post-sticking, animals subjected to captive bolt stunning and those that had not been stunned had significantly higher muscle pH readings than the electrically stunned sheep. At 24 h post-sticking, animals subjected to captive bolt stunning had significantly higher pH values than those that were not stunned, which, in turn, had significantly higher values than electrically stunned sheep.

There was a significant difference between the colour of meat from sheep from the different groups ($P < 0.05$): meat from captive bolt stunned sheep was the darkest, followed by that from sheep with no stunning, whilst meat from electrically stunned sheep was the lightest.

There was no significant difference between the percentage blood loss after 90 s. Blood loss for all treatment groups was approximately 4% of the live weight. Figure 1 shows the mean blood loss, as a percentage of live weight, for each group post-sticking. This variable was used because of the variation in live weights between individual animals; in particular, the animals in the electrical stunning group were heavier.

The relationship between live weight and amount of blood loss post-sticking was examined. To correct for the range in live weights, the covariate 'live weight' was added to the analysis of variance model for all analyses on blood loss. Table 2 shows the adjusted means derived from analysis of covariance with slaughter method as a factor and live weight as a covariate. It can be seen from this table and from Figure 2 that the adjusted blood loss for all three groups is similar, with no significant differences between the groups. Total blood loss for sheep in the no-stunning group was 1.58 kg, a little lower than the 1.62 kg of blood that was collected from electrically stunned animals, but slightly higher than the 1.53 kg of blood collected from the captive bolt stunned animals. Again, there was no significant difference between the groups.

Another way of interpreting the results of blood loss was to examine the rate at which blood was collected following sticking — in particular, to compare the time taken to reach 25%, 50%, 75% and 90% of the total amount of blood lost during the 90 s bleed out period. Table 3 shows the mean times derived from the one-way ANOVA, with slaughter method as a factor. Animals that were not stunned took less time to bleed out 50% of their total blood compared to those in two stunning treatments, both of which had similar times. However, these differences were not significantly different. The average time taken to reach 90% blood loss was quickest in those animals that were electrically stunned. The slowest group to reach 90% blood loss was the no-stunning group. Again, there were no significant differences between the groups.

The live weights of the animals, as well as the weights of fleece and viscera, were taken into account when comparing the data on the total and rate of blood loss. Table 1 shows the average weights and total blood loss after the use of each slaughter method. The results indicate that slaughter

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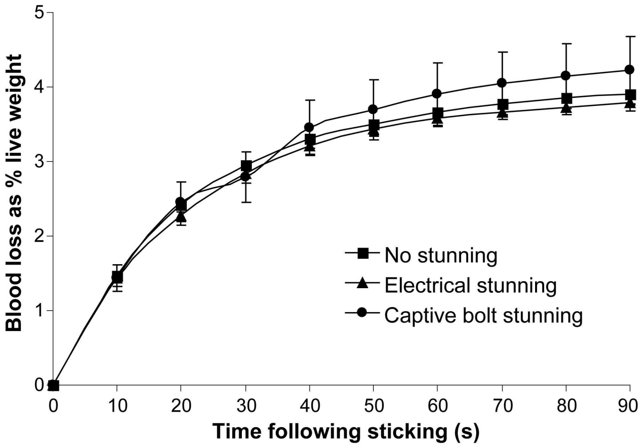
Table 2 Mean blood loss at 10 s intervals following different slaughter methods in sheep (adjusted means derived from the analysis of covariance with live weight as the covariate).

	Mean blood loss (kg)						
Time after neck cut (s)	No stunning	Electrical stunning	Captive bolt stunning	*df*	VR	Covariate significance	Stunning method significance
10	0.60	0.59	0.53	55	0.66	***	ns
20	0.97	0.94	0.90	54	0.30	***	ns
30	1.18	1.18	1.04	55	1.16	***	ns
40	1.31	1.35	1.25	54	0.42	***	ns
50	1.38	1.46	1.34	55	0.64	***	ns
60	1.45	1.52	1.41	55	0.51	***	ns
70	1.49	1.56	1.46	55	0.42	***	ns
80	1.52	1.59	1.50	55	0.39	***	ns
90	1.58	1.62	1.53	53	0.30	***	ns

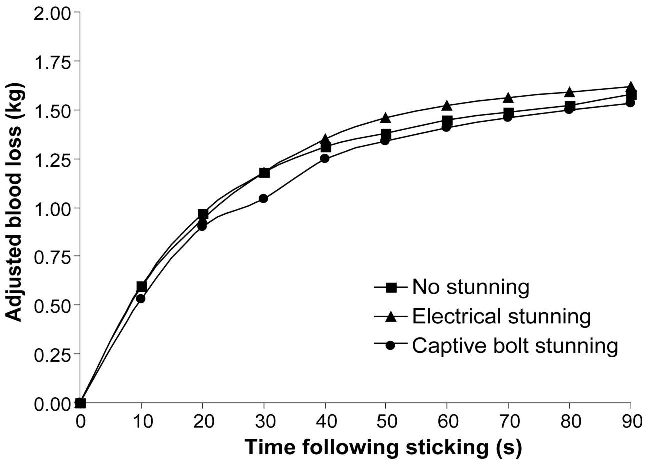
df = residual degrees of freedom
VR = variance ratio for the treatment
ns = not significant
*** $P < 0.001$

Figure 1



Mean (± SE) blood loss as a percentage of live weight following different slaughter methods.

Figure 2



Blood loss as a percentage of live weight following different slaughter methods (adjusted means derived from the analyses of covariance with live weight as the covariate).

without stunning and slaughter after electrical or captive bolt stunning did not influence the rate and total blood loss. In the case of electrical stunning, there was a tendency for the rate to increase initially, although this was not statistically significant. There was no evidence to suggest that slaughter without stunning could result in a better bleed out.

PCV levels were also not affected by the method of slaughter, remaining around the 36% level. Meat quality results did, however, show some differences: pH readings at 24 h remained relatively high at 6.2 in the captive bolt stunned group (Table 1). Similarly, colour measurements demonstrated darker meat in the same group.

Discussion

Although there are other requirements for both the Muslim slaughter method and Shechita (Anil & Sheard 1994), fast and effective blood loss during exsanguination is one of the essential requirements for meat produced by religious slaughter methods in order for it to be acceptable to Muslim and Jewish consumers. This requirement relates to welfare, as well as hygiene, as a rapid loss of blood should ensure quick loss of consciousness and death. As the consumption of blood is forbidden, as indicated in the Quran (Masri 1989) and Talmud (see Grunfeld 1972; Munk *et al* 1976; Levinger 1995), retention of blood in the carcass is also undesirable.

One of the arguments against stunning has been that it impedes blood loss. This study has demonstrated that there is no difference in bleed out effectiveness between no-stunning methods and common stunning methods that do not stop the heart (head-only electrical and captive bolt stunning). In fact, there was a tendency for electrical stunning to result in a better bleed out. This is not surprising since the passage of an electrical current will cause contraction of the muscle and vasoconstriction of the blood vessels through sympathetic stimulation. Warriss (1978) showed that stunned and slaughtered animals had less blood retention, as indicated by increased catecholamine levels,

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Table 3 Mean rate of blood loss following different slaughter methods.

	No stunning	Electrical stunning	Captive bolt stunning	*df*	VR	SED	Significance
Time to 25% blood loss (s)	5.7	6.7	6.4	56	1.24	0.71	ns
Time to 50% blood loss (s)	14.1	16.4	16.3	56	1.63	1.66	ns
Time to 75% blood loss (s)	31.8	30.8	27.0	56	1.12	3.19	ns
Time to 90% blood loss (s)	55.8	50.9	53.3	55	1.20	3.59	ns

df = residual degrees of freedom
VR = variance ratio
SED = standard error of difference between means
ns = not significant at $P < 0.05$

than those bled under anaesthesia. With regard to differences between stunning methods, Warriss and Leach (1978) found similar amounts of residual haemoglobin in electrically stunned and captive bolt stunned sheep. Kalweit *et al* (1989), comparing Shechita with stunning methods, found no difference in the amount of haemoglobin content in the longissimus dorsi muscle and the diaphragm in sheep. One study that reported a possible improved bleed out in the non-stunned group was carried out in broilers by Griffiths *et al* (1985), who found lower haemoglobin content in the bone marrow of non-stunned animals (blood having been released from the bone marrow into the bloodstream, and then lost during exsanguination), possibly as a result of flapping and excessive convulsions.

The welfare effects of stunning methods have been studied extensively in recent years, by examining the brain function (Bager *et al* 1992) and behaviour of different species (Blackmore 1984). Most studies have concentrated on loss of brain function. Daly *et al* (1988) found that the time to loss of brain responsiveness was significantly longer in cattle following Shechita (55 s) than following captive bolt stunning (immediate). With regard to bleed out, the present study has attempted to compare different methods directly, focusing on the Muslim method of neck cutting as the no-stunning treatment. It must be noted that the Jewish method, Shechita, carried out using a special, long, extremely sharp knife, was not available as a treatment. Although the Shechita cut involves severance of the same blood vessels and one would therefore expect a similar bleed out to that after the Muslim method, a comparable study involving Shechita would be useful.

Without doubt, variations in the success of any method can occur. Differences in bleed out can simply be due to the act of exsanguination — the neck cut. Inadequate cuts, resulting in carotid occlusion and restricted blood flow, have been shown to be a problem, especially in cattle (Anil *et al* 1995). An effective cut should lead to loss of brain responsiveness in less than 15 s (Gregory & Wotton 1984) in sheep, and longer in cattle (Kalweit *et al* 1989). When carotid occlusions occur in cattle, this can be delayed for as long as 120 s (Anil *et al* 1995). However, because of the anatomical differences between sheep and cattle (cattle possess an extra arterial branch to the head), a delay in bleed out should not affect the time to loss of brain responsiveness in sheep to the same extent as in cattle.

Although the main objective of this study was to examine blood loss, some quality analyses were also carried out. There was no apparent difference in PCV levels between treatments. This is probably not surprising as all the animals had been handled in a similar way prior to slaughter. There was, however, some effect on pH and meat colour. The pH levels were found to increase and colour was darker after captive bolt stunning compared to the other treatments. This is difficult to explain and should be treated cautiously. As it was possible to obtain only a small piece of neck muscle from each carcass for pH and colour analysis, this may have led to inconsistent or sometimes inaccurate readings. Meat quality effects would need to be revisited in future studies, which would allow samples to be taken that were more suitable for these measurements.

In conclusion, this study has shown that bleed out is not adversely affected in sheep by either electrical or captive bolt stunning, nor is it improved by a neck cut without stunning. Similar studies have recently been completed in cattle with similar results (MH Anil, unpublished data). Encouraging abattoirs to use stunning methods before religious slaughter could improve animal welfare.

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