THE EFFECT OF ENVIRONMENTAL FACTORS SUCH AS PRESLAUGHTER TREATMENT AND ELECTRICAL STUNNING ON THE OCCURRENCE OF HAEMORRHAGES IN THE SHOULDER OF SLAUGHTER PIGS

E. Lambooy and W. Sybesma, Research Institute for Animal Production "Schoonoord". P.O. Box 501. 3700 AM Zeist, The Netherlands.

INTRODUCTION

After the introduction of electrical stunning, haemorrhages in the muscles were observed (Anthony 1932; Warrington 1974). These haemorrhages were not only observed after electrical stunning, but also after concussion, captive bolt and CO_2-stunning. Compared to other stunning methods. electrical stunning caused the most haemorrhages (Kirton et al. 1981; Burson et al. 1983). The haemorrhages were found in muscles as well as in connective and fat tissues.

It was initially thought that the haemorrhages were partly caused by lack of vitamins (Hess 1960) or by diapedese (leakage of blood vessels) which was induced by stress (Mandrup 1966; Jemmi 1984). Rupture of blood vessels were observed by electron microscope both after electrical and captive bolt stunning in lambs. This might be caused by supercontraction of myofibrils and movement between muscles during strong contractions (Leet et al. 1977; Gilbert and Devine 1982). Increase of blood pressure and heart beats usually do not cause haemorrhages. but may increase the seriousness of the haemorrhage (Kirton et al. 1978).

Van der Wal et al. (1975) concluded from questionnaires as well as experimental investigations that marked tonic contractions of antagonistic muscles usually cause typical fractures in the glenoid cavity accompanied by haemorrhages in the *m. brachiales* and lateral caput of the *m. triceps brachii*.

In this study, experiments were designed in order to determine the relative importance of the voltage and stunning time, stress and muscle contractions in extent of haemorrhages.

MATERIALS AND METHODS

Location and degree of the haemorrhages

All shoulders were derinded and deboned. Cuts were made between and within muscles to aid in detecting

Table 1. Percentage and seriousness of the observed blood splashes (0 = no; 1 = minor; 2 = major; m = muscle; c = connective tissue) in the left (le) and right (ri) shoulders of slaughtered pigs electrically stunned with low (70 V, 10 s) and high voltage (475 V, 3 s). (Significant difference $p \leq 0.05$: + according X^2-test and * according the analysis of variance).

		low le (n = 51)			high le (n = 51)			low ri (n = 49)			high ri (n = 50)		
		0	1	2	0	1	2	0	1	2	0	1	2
m.supra spinatus	m	56.9	37.3	5.9*	74.5	25.5	*	73.5	24.5	2.0	72.0	28.0	
lateral	c	7.8	74.5	17.6	17.6	76.5	5.9	8.2	85.7	6.1	10.0	86.0	4.0
muscles around	m	60.8	37.3	2.0+	88.2	11.8	+	53.1	44.9	2.0+	76.0	24.0	+
caput humeri	c	51.0	49.0		68.6	31.4		24.5	75.5	+	56.0	44.0	+
fractures	m	100.0			100.0			95,9		4.1*	100.0		*
	c	100.0			100.0			95.9		4.1*	98.0	2.0	*
m.triceps brachii	m	43.1	37.3	19.6	51.0	41.2	7.8	49.0	46.9	4.1	40.0	48.0	12.0
lateral	c	49.0	47.1	3.9	45.1	52.9	2.0	40.8	57.1	2.0	40.0	60.0	
m.striceps brachii	m	92.2	7.8		98.0	2.0		95.9	4.1		92.0	8.0	
	c	33.3	66.7	+	60.8	39.2	+	40.8	59.2		56.0	44.0	
between m.triceps brachii	m	86.3	13.7		80.4	19.6		83.7	16.3		68.0	32.0	
and m.infra spinatus	c	35.3	64.7		49.0	51.0		30.6	69.4		20.0	80.0	
rest	m	51.0	43.1	5.9	76.5	23.5		51.0	46.9	2.0	68.0	32.0	
	c	51.0	45.1	3.9	54.9	43.1		26.5	73.5	+	50.0	50.0	+

Table 2. Percentage and seriousness of the blood splashes in the shoulders of slaughtered pigs stunned in the fattening pen or in the slaughterhouse(see Table 1).

		fattening pen le (n = 24)			slaughterhouse le (n = 21)			fattening pen ri (n = 24)			slaughterhouse ri (n = 22)		
		0	1	2	0	1	2	0	1	2	0	1	2
m.supra spinatus	m	75.0	25.0		81.0	14.3	4.8	62.5	37.5		72.7	22.7	4.5
lateral	c	16.7	79.2	4.2	28.6	52.4	19.0	16.7	75.0	8.3*	36.4	63.6	*
muscles around	m	95.8	4.2		90.5	9.5		100.0		+	68.2	31.8	+
caput humeri	c	95.8	4.2		80.5	9.5		100.0		+	72.7	27.3	+
fractures	m	95.8		4.2	100.0			100.0			95.5	4.5	
	c	95.8	4.2		100.0			91.7	8.3		95.5	4.5	
m.triceps brachii	m	100.0		+,*	42.9	42.9	14.3+,*	91.7	8.3	+,*	45.5	36.4	18.2+,*
lateral	c	100.0		+	66.7	33.3	+	91.7	8.3	+	72.7	27.3	+
m.triceps brachii	m	100.0			90.9	9.1		100.0			90.9	9.1	
	c	95.8	4.2		76.2	23.8		95.8	4.2		86.4	13.6	
between m.triceps brachii	m	91.7	4.2	4.2	81.0	19.0		95.8	4.2	+	63.6	36.4	+
and n.infra spinatus	c	29.2	70.8		42.9	57.1		45.8	54.2		31.8	68.2	
rest	m	87.5	12.5		100.0			95.8	4.2		95.5	4.5	
	c	100.0			100.0			79.2	20.8		90.9	4.5	4.5

Table 3. Percentage and seriousness of the blood splashes in the shoulders of slaughtered pigs stunned in a pen or in a restrainer (see Table 1).

		pen le (n = 25)			restrainer le (n = 25)			pen ri (n = 25)			restrainer ri (n = 24)		
		0	1	2	0	1	2	0	1	2	0	1	2
m. supra spinatus	m	44.0	56.0	+	80.0	16.0	4.0+	60.0	40.0	+,*	33.3	50.0	16.7+,*
lateral	c	4.0	92.0	4.0	0.0	76.0	24.0	0.0	84.0	16.0	8.0	58.3	33.3
muscles around	m	52.0	48.0	+	20.0	76.0	4.0+	44.0	56.0	+,*	12.5	75.0	12.5+,*
caput humeri	c	88.0	12.0		84.0	16.0		84.0	16.0		66.7	33.3	
fractures	m	100.0			100.0			96.0	4.0		100.0		
	c	100.0			100.0			96.0	4.0		100.0		
m. triceps brachii	m	80.0	20.0	+	28.0	56.0	16.0+	88.0	12.0	+,*	25.0	41.7	33.3+,*
lateral	c	88.0	8.0	4.0	68.0	32.0		100.0		+	66.7	33.3	+
m. triceps brachii	m	96.0	4.0		88.0	12.0		100.0		+	83.3	16.7	+
	c	76.0	24.0	+	44.0	56.0	+	76.0	24.0	+	37.5	62.5	+
between m. triceps brachii	m	76.0	24.0		76.0	24.0		72.0	28.0		79.2	20.8	
and m. infra spinatus	c	24.0	76.0		20.0	80.0		40.0	60.0		20.8	79.2	
rest	m	92.0	8.0		68.0	32.0		96.0	4.0		83.3	16.7	
	c	100.0		+	68.0	32.0	+	96.0	4.0		91.7	4.2	4.2

Table 4. Percentage and seriousness of the blood splashes in the shoulders of slaughtered pigs electrically stunned (475 V, 3 s) or anaesthetized with azaperone/metomidaat (see Table 1).

		electrical le (n = 24)			chemical le (n = 24)			electrical ri (n = 24)			chemical ri (n = 24)		
		0	1	2	0	1	2	0	1	2	0	1	2
m. supra spinatus	m	70.8	29.2	+	100.0		+	54.2	41.7	4.2+	100.0		+
lateral	c	16.7	79.2	4.2+	100.0		+	8.3	75.0	16.7+,*	100.0		+,*
muscles around	m	87.5	12.5		100.0			95.8	4.2		100.0		
caput humeri	c	87.5	12.5		100.0			95.8	4.2		100.0		
fractures	m	95.8	4.2		100.0			87.5		12.5*	100.0		*
	c	95.8		4.2	100.0			87.5		12.5*	100.0		*
m. triceps brachii	m	95.8	4.2		100.0			91.7	8.3		100.0		
lateral	c	87.5	12.5		100.0			95.8	4.2		100.0		
m. triceps brachii	m	100.0			100.0			91.7	8.3		100.0		
	c	95.8	4.2		100.0			91.7	8.3		100.0		
between m. triceps brachii	m	83.3	12.5	4.2	100.0			87.5	12.5		100.0		
and m. infra spinatus	c	33.3	66.7	+	100.0		+	25.0	75.0	+	100.0		+
rest	m	79.2	20.8	+	100.0		+	91.7	4.2	4.2	100.0		
	c	87.5	12.5		100.0			87.5	12.5		100.0		

haemorrhages. Haemorrhages were scored for position (which muscle). the quality (connective tissue or muscle) and the extent of the haemorrhage (0 - no haemorrhage; 1 - minor and 2 - major haemorrhage). Both left and right shoulders were observed. In four experiments the effect of different treatments on the occurrence of haemorrhages in the shoulders of slaughtered pigs were investigated.

Voltage and stunning time

In a slaughterhouse half of a group of 100 pigs were electrically stunned with 70 V during 10 s while the other half were stunned with 475 V during 3 s (Nijhuis equipment) using a scissor model tong. These stunning durations are usual for both voltages. The duration between stunning and sticking was 15 to 20 s.

Transport effect

Three weeks before slaughter a group of 50 pigs were placed in a stable at the institute's farm. Half of these pigs were electrically stunned with 475 V during 3 s with the mentioned equipment and bled near the fattening pen and slaughtered in the institute#s slaughterhouse. The duration between stunning and sticking was 15 to 25 s. The other half of pigs were transported the next day and slaughtered in the slaughterhouse as in the first experiment. All animals were stunned with the same stunning equipment (475 V, 3 s).

Muscle restriction

Half of a group of 50 pigs were electrically stunned in a V.type restrainer. The other half were stunned while free moving in a pen. Both groups were stunned with or without restraining with the same equipment (475 V, 3 s). The duration between stunning and sticking was with restraining and without restraining 15 to 20 s and 20 to 30 s, respectively.

Muscle sedation

Three weeks before slaughter a group of 50 slaughter pigs were placed at the institute's farm. Half of the group of pigs was electrically stunned (475, 3 s) while free moving in the institutes slaughterhouse. The duration between stunning and sticking was 10 to 15 s. The other half of the group was sedated with 6 cc azaperone (Stressnil®) i.m. per animal and anaesthetized with 10 cc metomidaat (Hypnodyl®) i.v. per animal and bled.

Statistical analysis

The data were analysed with the X^2-test and a least square method of analyses of variance. At the X^2-test the seriousness of the blood splashes was compared between the different treatments while at the analysis of variance

no and minor blood splashes were compared with major blood splashes between treatments.

RESULTS

Voltage and stunning time

It was observed that blood splashes were mostly restricted to some locations, as shown in Table 1 to 4. Frequency and seriousness of haemorrhages were observed to be significantly higher ($P < 0.05$) after low voltage stunning than in high voltage stunning (Table 1). There is a general trend of less blood splashes with high voltage.

Transport effect

Blood splashes were lower in frequency and seriousness after stunning and bleeding near the fattening pen compared with stunning after transportation to the slaughterhouse. The *m. triceps brachii* (Table 2) showed less haemorrhages than other muscles.

Muscle restriction

In nearly all muscles of both left and right shoulders significantly more blood splashes were found after stunning in a V-type restrainer. Only fractures were observed after stunning while free moving in a pen (Table 3).

Muscle sedation

It appeared clearly that blood splashes were observed after electrical stunning while no blood splashes at all were found after chemical stunning (Table 4).

DISCUSSION

The visual analysis of the blood splashes made clear that certain predilection sites exist. These were the lateral part of the *m. supra spinatus* and the *m. triceps brachii* and around the *caput humeri*. These findings are in accordance with the results of Van der Wal (1975). It is remarkable that blood splashes occurred at the same locations in the shoulder. The predisposition may be due to a higher traction in the tissue which may be a result of direct electrical stimulation of the muscles and reaction of the epileptiform insult.

In lambs a longer stunning duration or higher currents appeared to increase blood splashes (Devine et al. 1983). In shoulders of slaughtered pigs a longer duration of stunning was observed to be of more importance for increased blood splashes than a higher voltage (and currents). A shorter stunning and stun-stick duration diminished blood splashes, because it shortened the duration of bleeding (Kirton et al. 1978).

Haemorrhages seemed to be caused by electrical stunning, however. stress and restraining may also be important factors (Jemmi 1984).In our experiment we found a significant difference in blood splash percentage between slaughter in the stable and in the slaughterhouse. However, in the slaughterhouse the pigs were stunned in a V.type restrainer, which may have caused the higher degree of blood splashes as indicated by the next experiment. Because the animal is in an unnatural position in a V.type restrainer, haemorrhages during and after stunning may be caused by movements during strong contractions (Gilbert and Devine 1982; Lambooy 1986). Our experiments support this view.

Blood splashes are observed after all stunning methods (Kirton et al. 1981) and may be caused by rupture of blood vessels after contractions of muscles (Leet et al. 1977). An increased percentage of haemorrhages after electrical stunning may be caused by a high energy input and consequently direct stimulation of the muscles, while after chemical anaesthesia no blood splashes at all were observed.

It may be concluded from these experiments that certain treatments have a favourable effect on the amount of blood splashes. However, the percentage is still too high. Therefore methods have to be developed which combine the rapid unconsciousness by electrical stunning and a low stimulation of the muscle in pigs.

SUMMARY

In four experiments the effect of different treatments on the occurrence of blood splashes in the shoulders of slaughtered pigs were investigated. The treatments with 50 pigs each were as follows: 1) low voltage (70 V, 3 s) versus high voltage (475 V, 3 s); 2) stunning in the fattening pen versus in the slaughterhouse; 3) stunning in a pen versus in a restrainer; 4) electrical versus chemical stunning. High voltage and stunning in a pen showed less blood splashes compared with their opponent experiment. Chemically stunned pigs showed no haemorrhages at all in contrast to electrically stunned pigs.

Certain treatments may have a favourable effect on the amount of blood splashes. Methods have to be developed which combine rapid unconsciousness and low stimulation of the muscles in pigs.

REFERENCES

Anthony, D.J. (1932). *Veterinary Record* **12**:380-386.

Burson, D.E., Hunt. M.C., Schafer, D.E., Beckwith, D. and Garrison J.R. (1983). *Journal of Animal Science* **57**(4):918-921.

Devine, C.E., Gilbert, K.V. and Ellery, S. (1983). *Meat Science* **9**:247-256.

Gilbert, K.V. and Devine, C.E. (1982). *Meat Science* **7**:197-207.

Hess, E. (1960). *Fleischwirtschaft* **12**:634-635.

Jemmi, T. (1984). Thesis, Bern.

Kirton, A.H., Bishop. W.H., Mullord, M.M. and Frazerhurst. L.F. (1978). *Meat Science* **2**:200-206.

Lambooy, E. (1986). Proceedings 32nd European Meeting of Meat Research Workers, Ghent.

Leet, N.G., Devine, C.E. and Gavey, A.B. (1977). *Meat Science* **1**:229-234.

Mandrup, M. (1966). *Acta Vererinaria Scandinavia* **7**:394.

Wal. P.G. van der, Nieuwenhuysen, H.Th., Sybesma. W. and Scholten. J.I.M. (1975). *Tijdschrift voor Diergeneeskunde* **100**:597-603.

Warrington. R. (1974). *Veterinary Bulletin* 44(10):617-635.