B2.

THE STRESS SYNDROME AND MEAT QUALITY

HALOTHANE AND THE STRESS SYNDROME IN PIGS

J.V.McLOUGHLIN and CARMEL MOTHERSILL

Department of Pre-Clinical Veterinary Sciences,

Trinity College, Dublin 4, Ireland

and

Agricultural Institute,

Castleknock, Co. Dublin, Ireland.

Inhalation of a mixture of nitrous oxide and oxygen containing halothane proved to be a satisfactory procedure for anaesthetising Irish Landrace pigs. Pietrain pigs rapidly developed a marked rigidity of the extensor muscles of the limbs, tachycardia and polypnea. The rigidity was not relaxed by the administration of d-tubocurare nor was it induced by nitrous oxide and oxygen in the absence of halothane. Muscle temperatures up to 44°C were recorded. Examination of the red and white fibre areas of m. semitendinosus showed that considerable turnover of ATP, depletion of creatine phosphate and accummulation of lactate had occurred in Pietrain muscle in vivo.

HALOTHANE AND THE STRESS SYNDROME IN PIGS

J.V.McLoughlin

Department of Pre-Clinical Veterinary Sciences,
Trinity College, Dublin 4, Ireland

and

Carmel Mothersill

Agricultural Institute,
Castleknock, Co. Dublin, Ireland.

INTRODUCTION

The anaesthetic halothane (2-bromo-2-chloro-1,1,1-trifluoroethane) has been associated with the development of malignant hyperpyrexia in the pig (Harrison et al., 1968; Berman et al., 1970; Woolf et al., 1970; Berman and Kench, 1971). The syndrome is characterised by an uncontrolled rise in body temperature and muscular rigidity. In certain respects the condition resembles the porcine stress syndrome (Topel, 1968) and the pale soft exudative (PSE) muscle condition which develops post-mortem (cf. Briskey, 1964). There is evidence which suggests that the predisposition to malignant hyperpyrexia may have a genetical basis (Harrison et al., 1969; Woolf et al., 1970).

In the work reported here, the effects of halothane on the skeletal muscle of Pietrain and Irish Landrace pigs were studied. The Pietrain is a highly stress-susceptible breed and the onset of malignant hyperpyrexia has been associated with forms of stress such as severe exercise (Sybesma and Eikelenboom, 1969) and halothane anaesthesia (Allen et al., 1970). The Irish Landrace on the other hand appears to be relatively resistant to stress and has a low incidence of PSE muscle (McLoughlin, 1965).

EXPERIMENTAL

Animals

Pure bred Irish Landrace and Pietrain pigs were used in this investigation. The Pietrains were bred from stock imported for experimental purposes from the University of Newcastle-upon-Tyne, U.K. The live weights of the animals ranged from 90 to 110 Kg at the time of the experiments. Females and male castrates were randomly selected. The animals were kept in the laboratory overnight so that they were subjected to as little stress as possible just before each experiment.

Anaesthesia

A bag was placed over the animals head and it was permitted to breathe a mixture of nitrous oxide (u 1./min.) and oxygen (3 1./min.) containing approximately 2% of halothane (Hoescht, Germany). When the animals lost consciousness they were placed on an operating table, a tracheotomy was performed, a tube inserted and the cuff inflated. Anaesthesia was maintained in this way until specimens of muscle had been removed. The animals were then sacrificed by exsanguination.

Muscle

M. semitendinosus was removed from the live animal. Specimens of the predominantly red and white fibre areas were taken immediately for analysis and the muscle placed at 37°C under a stream of moist nitrogen to ensure anaerobic conditions. Samples were removed at intervals up to 180 min.

Biochemical Analysis

Extracts of tissue in perchloric acid (0.6 M) were prepared. Creatine phosphate (C P), ATP and glucose-6-phosphate (G-6-P) were assayed using creatine phosphate kinase, hexokinase, glucose-6-phosphate dehydrogenase, glucose and NADP. Lactate was determined using lactic dehydrogenase according to the procedure described by Hohorst (1963), glycogen by the method of Seifter et al., (1950). The pH of muscle was determined on suspensions (20% W/V) of tissue in iodoacetate (5 mM) neutralised to pH 7.0.

RESULTS

Pietrain pigs used in the experiments developed an extreme rigidity of the skeletal musculature within 5 min of exposure to halothane. The heart rate accelerated and respiration became shallow and appeared to be maintained by the movements of the diaphragm. Large cyanotic patches appeared on the skin. Muscle temperatures (m. longissimus dorsi) up to 44°C were recorded. The striking feature of the condition was the marked contraction of extensor muscles so that the limbs were outstretched and virtually inflexible. The animals were in a state which resembled rigor mortis in vivo.

Two pigs were given d-tubocurarine chloride (0.5 mg./Kg.) when rigidity had developed but the neuromuscular blocking agent did not bring about relaxation. A further two pigs given nitrous oxide and oxygen only for 30 min did not show signs of rigidity. When halothane was then included rigidity developed. Halothane was then discontinued but nevertheless the animals died about 20 min later. Landrace pigs did not show any adverse response to halothane and the musculature remained relaxed during anaesthesia.

Biochemical Aspects of Muscle

The C P content of both red and white fibres was virtually depleted in muscle removed in vivo from the Pietrain pigs whereas Landrace muscle contained 22.8 ± 1.7 umole CP/g. in the white fibres and 16.2 ± 1.7 umole/g. in the red (Fig.1). The initial concentration of ATP was higher in the Landrace (white fibres 5.8 ± 0.3, red 4.5 ± 0.2 umole/g.) than in Pietrain (white fibres 3.4 ± 1.2, red 3.2 ± 0.7 umole/g.) and there was a high net loss of ATP from Pietrain muscle after 60 min whereas the concentration of ATP in Landrace muscle fell slowly over 180 min. The initial pH of Landrace muscle was appreciatively higher than that of Pietrain in both the red and white fibre areas although the subsequent rate of pH fall was similar in both breeds (Fig.3). The initial levels of lactate (Fig.4) were much higher in Pietrain muscle (white 53.4 ± 13, red 40.6 ± 9.7 umole/g.) than in Landrace (white 8.4 ± 1.7, red 7.6 ± 1.1 umole/g.). Lactate was produced at approximately the same rate in muscle of both breeds over the following 120 min. The glycogen levels (Fig.5) of Landrace muscle (white 11.7 ± 0.4, red 8.7 ± 1.1 mg./g.) were higher than those of Pietrain (white 4.9 ± 1.4, red 2.7 ± 0.9 mg./g.).

The ATP, C P, G-6-PO_4, lactate and glycogen contents and the pH of m. semitendinosus of Pietrain pigs which were exsanguinated without prior stunning or premedication are given in Table 1. The values for muscle removed immediately post-mortem are similar to those for muscle taken from Pietrain pigs under halothane anaesthesia.

DISCUSSION

Halothane anaesthesia rapidly caused severe muscular rigidity to develop in Pietrain pigs but did not similarly affect Landrace. Rigidity was accompanied by a high rate of turnover of ATP in the muscle since the C P content was depleted and considerable amounts of lactate had accummulated in the tissue in vivo. Activation of the muscle ATP hydrolases must clearly have followed the administration of halothane. The mechanisms involved are a matter for speculation but it is possible that the capacity of the triads and longitudinal elements of the sarcoplasmic reticulum to rebind calcium ions might have been reduced since many anaesthetic agents act via their effects on biological membranes. The response of Pietrains to the anaesthetic and the absence of any response in Landrace indicates that the sensitivity to halothane has a genetical basis and may be related to the general stress susceptibility of the Pietrain breed.

REFERENCES

Allen, W.M.; Berrett, S.; Harding, J.D.J. and Patterson, D.S.P. 1970 Experimentally induced acute stress syndrome in Pietrain pigs. Vet. Rec. 87, 64.

Berman, M.C.; Harrison, G.G.; Bull, A.B. and Kench, J.E. 1970 Changes underlying halothane induced hyperpyrexia in Landrace pigs. Nature (Lond.) 225, 653.

Berman, M.C. and Kench, J.E. 1971 Muscle metabolism during anaesthetic induced hyperthermia. Proc. 2nd Internat. Symp. on Condition and Meat Quality in Pigs. Pudoc, Wageningen. p. 29.

Harrison, G.G.; Biebuyck, J.F.; Terblanche, J.; Dent, D.M.; Hickman, R. and Saunders, S.J. 1968 Hyperpyrexia during anaesthesia. Brit. Med. J. 3, 594.

Harrison, G.G.; Saunders, S.J.; Biebuyck, J.F.; Hickman, R.; Dent, G.M.; Weaver, V. and Terblanche, J. 1969 Brit. J. Anaesth. 41, 844.

Hegarty, P.V.J. and Naude, R.T. 1970 The accuracy of measurement of individual skeletal muscle fibres separated by a rapid technique. Lab. Pract. 19, 161.

Hohorst, H.J. 1963 Determination with lactic dehydrogenase and DPN. In Methods of Enzymatic Analysis p.268. Ed. Bergmeyer, H.U. Acad. Press, N.Y. and Lond.

McLoughlin, J.V. 1965 Studies on pig muscle I Exudative pig muscle. Irish J. Agric. Res. 4, 151.

Seifter, S.; Dayton, S.; Novic, B. and Muntwyler, E. 1950 The estimation of glycogen with the anthrone reagent. Arch. Biochem. 25, 191.

Sybesma, W. and Eikelenboom, G. 1969 Malignant hyperthermia syndrome in pigs. Neth. J. Vet. Sci. 2, 155.

Woolf, N.; Hall, L.; Thorne, C.; Down, M. and Walker, R. 1970 Serum creatine phosphate kinase levels in pigs reacting abnormally to halogenated anaesthetics. Brit. Med. J. 3,386.

TABLE I
M. semitendinosus immediately post-mortem
(untreated Pietrain pigs)

	White fibres	Red fibres
C ~ P	1.7 ± 0.4	1.1 ± 0.2
ATP	4.3 ± 0.2	3.4 ± 0.4
Lactate	55.9 ± 13.0	45.6 ± 4.1
Glycogen[1]	6.2 ± 0.8	3.4 ± 0.5
G-6-PO_4	0.1 ± 0.3	0.1 ± 0.4
pH	6.36± 0.10	6.36± 0.36

1 mg./g., others umole/g.