of the period of stimulation both inhibitory and excitatory nerve fibers were active and that rebound excitation followed the cessation of the inhibitory discharge. An example of a depolarizing response is shown in Figure 1C. During repetitive nerve stimulation (ganglion severed) depolarization gradually increased (Figure 1C). Spontaneous oscillation sometimes was apparent even before the beginning of nerve stimulation (Figure 1D). As depolarization grew, in response to repetitive nerve stimulation, the oscillation increased correspondingly in amplitude. At the arrow (Figure 1D) stimulus strength was increased. When the cardiac nerve was stimulated just at inhibitory threshold intensity, compound nerve action potentials appeared, of intermittently fluctuating amplitude, as in the first part of the record in Figure 2A. The largest of these nerve action potentials induced unitary inhibitory junctional potentials. When suprathreshold stimulation was given (arrow) repetitive large compound nerve action potentials evoked repetitive summating inhibitory junctional potentials. These may hold the membranes hyperpolarized.

In Figure 2B, we see that rebound excitation from inhibitory junctional potentials and usual excitation from excitatory junctional potentials can occur at the same time. Nerve stimulation first induced hyperpolarization, but then depolarization prevailed. An action potential followed cessation of stimulation. It may be thought that this kind of overlapping action causes especially rapid and strong excitation[8].

Résumé. Les auteurs ont étudié, par microélectrode interne, l'interaction entre les potentiels postsynaptique inhibitoire et excitatif dans un myocarde myogénique. Ils ont observé la sommation de ces potentiels et leur action facilitant l'inhibition par hyperpolarization et l'excitation par depolarisation.

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Decreased Blood P_{CO_2} in the Ovine Foetus During Hyperthermia: Implications for Increased Placental Blood Flow

During experiments designed to examine factors determining the onset of parturition and the time at which the foetus first becomes thermosensitive, we have observed that thermally-induced hyperventilation in the ewe caused a far greater depression of P_{CO_2} in foetal, as opposed to maternal blood; a likely explanation for this is that placental blood flow increased.

It has recently been shown that in the conscious sheep, the difference between maternal and foetal blood P_{O_2}, P_{CO_2} and pH remained virtually constant during small fluctuations in these parameters[1]. However, large changes in blood gas status of the ewe induced by artificial hyperventilation or by administration of gas mixtures, resulted in wide variations in the materno-foetal blood P_{O_2} difference, whereas the P_{CO_2} difference remained essentially constant. These latter studies were performed either with the ewe under general anaesthesia and the foetus in utero[2], or with the ewe under spinal anaesthesia and the foetus partly exposed[3].

Methods. One Merino × Merino (sheep No. 1) and 2 Border Leicester × Merino (sheep Nos. 2 and 3) foetuses were surgically perpared and maintained with a vinyl catheter (1 mm i.d., 2 mm o.d.) in the left common carotid artery as described by BASSETT, THORBURN and WALLACE[4]. At the same operation a copper-constantan thermocouple (38 swg.) clad in vinyl was sutured into the sheath of the right common carotid artery of the foetus and ewe to permit the monitoring of foetal and maternal arterial blood temperatures (T_{ar} ±0.05°C). Blood samples (2 ml) were drawn into chilled, heparinized syringes. The P_{O_2}, P_{CO_2} and pH were measured at 38°C using a Radiometer BMS 3 electrode system, and corrected to the animals' temperature with appropriate factors[5,6], shown to be applicable to the sheep[7]. Oxyhaemoglobin saturation (S_{O_2}) was measured using an Instrumentation Laboratory CO-Oximeter (Model 182) calibrated for use with sheep blood[8].

Animals were housed together in a climatic room with an ambient dry bulb temperature of approximately 16°C. Observations were made on sheep Nos. 2 and 3 during the last 16 days of the 150 days gestation period. A moderate heat stress was imposed between day −14 and −10 of pregnancy (day 0 is day of birth) by raising the ambient temperatures to 40°C dry bulb and 26°C wet bulb. Temperatures of the ewe and foetus were recorded continuously for 1 h periods in the early morning, midday and late afternoon of every day; a blood sample was drawn from the foetus during each morning period. Sheep No. 1 was studied from day −26 but observations relevant to the present report were made only on day −25. This preparation had additional catheters, 1 in an umbilical vein of the foetus and 1 in a maternal common carotid artery. On day −25 temperatures were monitored continuously for $1^1/_2$ h before, 3 h during and 2 h after exposure to moderate heat stress; 2 blood samples were taken before and after, and 3 during heat exposure.

Results and discussion. Individual results for each animal are summarized in the Table, wherein mean values are given for the various parameters during the control periods (pre- and post heating) and during heat exposure. Foetal T_{ar} was normally 0.4–0.5°C higher than maternal

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T_{ar}. This confirms previous observations on the sheep[9] and man[10,11] and would support the view that the foetus loses heat to the mother and is not normally warmed by the mother as has been suggested[12,13]. During heat stress T_{ar} increased by 0.4–1.9°C in the foetus but by only 0.2–1.7°C in the ewe. This may be indicative of an increase in metabolic rate of the hyperthermic foetuses. A greater increase in foetal than in maternal temperature would also result if placental blood flow decreased. However, the following discussion shows this to be highly improbable in the present situation.

Our control values for the P_{O_2}, P_{CO_2} and pH of foetal carotid and umbilical vein blood generally approximate those previously reported for acute[1,14,15] or chronic preparations[1]. Exposure to mild heat stress for 4 days or only 3 h resulted in a slight increase in foetal carotid P_{O_2}, whereas P_{CO_2} decreased by 14–19 mm Hg. Because foetal carotid blood is a mixture of blood from the umbilical vein ('arterialized') and other veins, it was important to confirm that these results were reflecting the true status of the foetal blood supply; concurrent observations on blood from the umbilical vein and carotid artery of sheep No. 1 showed this to be so. An increase in pH would be expected to follow from the hypocapnia, but this occurred in only 1 of the 3 foetuses, there being a slight decrease in the other two. There was no significant change in S_{O_2}.

During mild heat stress the ewes exhibited rapid shallow panting with a respiratory frequency of 150–240 breaths/min. It is well established that under these contions, arterial P_{CO_2} decreases by 3–7 mm Hg[7,16], and this was confirmed in the present study on the one ewe in which P_{CO_2} was measured. It is therefore surprizing that the foetuses showed a decrease of at least twice this magnitude. This effect is even more remarkable when it is recognized that the changes in foetal CO_2 and O_2 status are, in fact, in the opposite direction to that which would be expected to follow an increase in metabolic rate induced an increase in body temperature (Q10 effect).

Effects of heat exposure on thermal and blood gas status of the ewe and foetus in utero

Parameter	Sheep No.	Thermoneutral	Heat
Foetal T_{ar} (°C)	1	40.0	40.4
	2	39.2	40.9
	3	39.1	41.0
Maternal T_{ar} (°C)	1	39.5	39.7
	2	38.7	40.4
	3	38.7	40.4
Foetal $P_{ac\,o_2}$ (mm Hg)	1	55.4	40.1
	2	48.0	29.3
	3	49.6	35.4
Foetal $P_{uvc\,o_2}$ (mm Hg)	1	48.9	33.4
Maternal $P_{ac\,o_2}$ (mm Hg)	1	33.6	26.6
Foetal pH_a	1	7.28	7.33
	2	7.31	7.29
	3	7.31	7.26
Foetal pH_{uv}	1	7.30	7.35
Maternal pH_a	1	7.44	7.51
Foetal $P_{a\,o_2}$ (mm Hg)	1	31.6	31.2
	2	36.0	38.7
	3	34.5	39.2
Foetal $P_{uv\,o_2}$ (mm Hg)	1	41.4	42.7
Maternal $P_{a\,o_2}$ (mm Hg)	1	110.0	108.7
Foetal $S_{a\,o_2}$ (%)	2	61.5	61.7
	3	61.8	59.3

T_{ar}, arterial temperature; subscripts *a* and *uv* in conjunction with blood gas tensions, pH and oxyhaemoglobin saturation indicate carotid artery and umbilical vein blood.

During maternal hypocapnia induced by artificial hyperventilation in the anaesthetized sheep, foetal and maternal blood P_{CO_2} levels follow one another closely[2,14]. The present disproportional decrease in foetal P_{CO_2} would be explicable on the basis of an increase in maternal placental blood flow, or an increase in the diffusion coefficient for CO_2 in the placental tissues. However, the diffusion coefficient for CO_2 is normally so high that a significant increase seems less likely to have occured, than does an increase in blood flow. If maternal placental blood flow increased, then an increase in foetal P_{O_2} and S_{O_2} might also have been expected, but only insignificant changes were recorded. Nevertheless, this does not conflict with the hypothesis, and is not entirely unexpected for two reasons. Firstly, there appears to be some form of O_2 diffusion barrier across the ovine placenta, since even during oxygen administration to the ewe, the umbilical P_{O_2} remains relatively constant[2]. Secondly, the P_{O_2} and S_{O_2} are markedly influenced by alterations in foetal metabolic rate and shifts in the oxyhaemoglobin dissociation curve caused by CO_2, pH and temperature changes.

The conditions of our experiments differ in two major respects from those previously reporting the foetal consequences of maternal hypocapnia, viz., the absence of anaesthesia and the presence of hyperthermia in our animals. It appears unlikely that anaesthesia would be responsible for the differing results[1,2]. An obvious interpretation therefore, is that the mother is sensitive to foetal temperature and that the apparent increase in placental blood flow is brought about in an attempt to combat the rising foetal temperature.

Finally, the present results may have some clinical implications. During times of foetal distress, particularly during parturition, maternal hyperoxaemia is frequently induced by increasing the inspired O_2 content or by voluntary hyperventilation. This leads to foetal acidosis with very little increase or even a decrease in foetal blood oxygen levels (see discussion by MOTOYAMA, RIVARD, ACHESON and COOK[14]). In these instances an increase in placental blood flow would probably be beneficial to the foetus, and it might be suggested that this could be induced by raising foetal temperature[17].

Zusammenfassung. Bei Wärmebelastung trächtiger Schafe ergibt sich eine wahrscheinliche Zunahme der Placentardurchblutung (mütterlicher Kreislauf), welche einer erwarteten Zunahme von P_{CO_2} im foetalen Blut entgegenwirkt.

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