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## *Short Communications and Technical Notes*

# Unilateral Splanchnotomy: Its Effect on the Response to Intra-Abdominal Heating in the Ewe*

Robert O. Rawson and Kenneth P. Quick

The John B. Pierce Foundation Laboratory
New Haven, Connecticut, U.S.A.

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*Summary.* We have demonstrated in previous studies that localized intra-abdominal heating of the ewe by means of electric heat sources implanted adjacent to the body wall on the right and left sides within the abdomen initiated panting in a neutral environment, and depressed metabolic heat production in a cold environment, with either no change or a depression of the several body temperatures measured. We have now found that unilateral section of the splanchnic nerves abolishes the typical response to intra-abdominal warming on the operated side without changing the response to warming on the opposite side. This result lends further support to our hypothesis of the existence of important thermoreceptors in the walls of the intestine and rumen, and implicates the splanchnic nerves as the pathway for impulses from these receptors.

*Key words:* Unilateral Splanchnotomy — Intra-Abdominal Thermoreceptors — Intra-Abdominal Afferents — Ewe Splanchnotomy.

In previous reports we have demonstrated that when localized heat was applied within the abdomen of the ewe in a 20° C environment, panting was initiated, or when the animal was shivering in the cold, metabolic heat production was depressed [1—3].

When the surface temperature of the heat sources was raised to 42—44° C there was an almost immediate rise in respiratory frequency and respiratory evaporative heat loss in neutral or warm environments, accompanied by a marked decline of hypothalamic temperature, and no change or a decline of vaginal temperature. In a cold environment, intra-abdominal warming depressed metabolic heat production, with a concomitant decline in vaginal temperature. Our results showed that the change of the thermoregulatory response in watts per kilogram of body weight was generally about twice the heat input in watts per kilogram. The data were interpreted as evidence that we were stimulating deep-body thermoreceptors located in the walls of the rumen and intestine. We

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also believe that the data presented negated the possibility that we were stimulating thermoreceptors located in the spinal cord, or skin or muscle of the body wall.

To further rule out this possibility and also to investigate the afferent neural pathways serving these thermoreceptors, it was decided that a denervation study was in order. We have repeated our experiments on two sheep, before and after unilateral splanchnotomy, and have observed the effect of the denervation upon the depression of metabolic heat production which has been shown to accompany intra-abdominal heating in the ewe.

## Methods

Each of the sheep employed in this study was implanted, through a standard paramidline laparotomy, with four specially designed heat sources 5.5 cm wide, 16 cm long and 1.0 cm thick. A pair of heaters was sutured side by side to the right and left abdominal wall. On the right, about 90% of the medial heater surface was touching the rumen, and on the left the heat sources contacted the intestine. Through exteriorized wire leads, electric current was supplied to produce a controlled heater surface temperature of 42—44° C with a power dissipation of up to 20 watts. A description of the construction, calibration and method of calculating in vivo surface temperatures of these devices, along with the surgical procedures employed in preparing the animals, have been reported in detail [1].

Metabolic heat production was calculated by an on-line computer from a continuous measurement of oxygen deficit in the exhaust air of a face mask which the sheep were trained to wear.

Vaginal temperature was measured with a copper-constantan thermocouple probe in a Teflon sheath placed 10 cm within the vagina. Hypothalamic temperature was monitored by a similar thermocouple inserted into a permanently implanted stainless steel re-entrant tube stereotaxically placed with its sealed distal end in the anterior region of the hypothalamus. The latter temperature was observed to either remain unchanged or decline during the experimental procedure. Changes in hypothalamic temperature were therefore not considered to be responsible for the responses observed, and a record of this temperature has not been included in the figures for the sake of simplicity.

The splanchnic nerves in sheep can be seen as the greater and lesser nerves running close together, along with some fine fibers which constitute the least splanchnic. These were exposed on one side through a four inch incision bisecting the angle between the last rib and the vertebral column. By reference to the adrenal gland the nerves were located and cut as they entered the adrenal plexus. Seven to ten days were allowed for recovery.

### *General Procedure*

Experiments were performed on the non-fasted ewes at approximately the same time each morning. The animals were close sheared at the beginning of the experimental series without subsequent shearing, since fleece length did not modify the quality of the response studied.

Experiments were conducted in a climate chamber with temperatures controlled to ± 0.5° C. Animals were allowed to equilibrate to cold ambient temperatures beginning 5 p.m. on the day prior to an experiment. Monitoring instrumentation was secured in place at least 1 h before recording was begun.

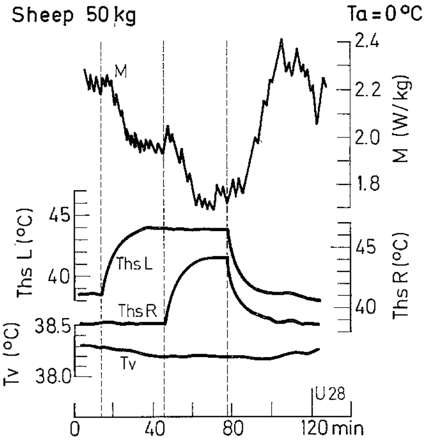


Fig. 1

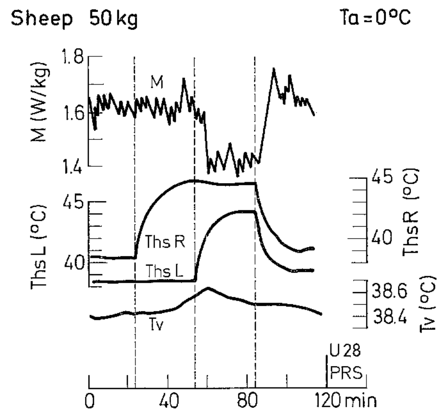


Fig. 2

Fig. 1. The reduction of metabolic heat production in the ewe upon warming the abdominal viscera by means of implanted electric heat sources. Plotted from the top are the metabolic heat production (*M*) in watts per kilogram of body weight, the surface temperature of two heaters on the left side (*Ths L*), two on the right side (*Ths R*), and vaginal temperature (*Tv*). *Ta* environmental temperature

Fig. 2. Abolition of one half of the total response shown in Fig. 1 following right unilateral splanchnotomy in the same ewe. Parameters plotted are identical to those in Fig. 1

The ewes were tested several times in cold environments prior to splanchnotomy to accumulate substantial data on their responses to intra-abdominal heating. After a convincing profile was established for each, and the ewe was denervated according to the procedure described, the tests were repeated. In these experiments a pair of internal heaters on one side was activated, and then those on the other side were turned on. The tests were repeated several times on each ewe, reversing the order of heating of the right and left pairs of heaters.

## Results

Fig. 1 shows the typical response of metabolic heat production to intra-abdominal heating in a 0° C environment prior to unilateral denervation. When heat was applied to the left pair of heaters *(Ths L)*, metabolic heat production *(M)* measured as oxygen consumption, declined rapidly 0.2 watt per kilogram below the control level. Adding heat to the right side, as indicated by the curve labelled *Ths R*, resulted in another 0.2 watt per kilogram decline of M. Over the 60 min heating period vaginal temperature *(Tv)* slowly declined, and proceeded to rise again following termination of the heat stimulus.

Fig. 2 shows data from the same procedure on the same ewe following a right unilateral splanchnotomy. When the heaters on the right side were warmed *(Ths R)*, no change occurred in the level of *M*, and vaginal temperature *(Tv)* rose slightly reflecting the addition of internal heat to the existing level of metabolic heat production affecting the temperature of the blood supply to the vagina. When the heaters on the left or unoperated side were warmed, *M* declined about 0.2 watt per kilogram, as it did prior to right unilateral splanchnotomy.

These experiments were repeated on two sheep, one with a right and one with a left unilateral splanchnotomy. The order of heating was reversed several times. In every instance the response of a decline in metabolic heat production to intra-abdominal warming was absent on the denervated side.

## Discussion

It is apparent from the results reported that section of the splanchnic nerves on one side abolished on that side the typical response of M to intra-abdominal heating. Since an identical stimulus to the unoperated side produced the same response as prior to the denervation procedure, it is not likely that unilateral denervation of the adrenal gland was responsible for the results observed.

In every experiment on the ewes prior to denervation, unilateral and then bilateral heating elicited depressions of metabolic heat production of the same orders of magnitude regardless of which side was heated first. In the denervated ewes however, the same heat input produced approximately one-half of the total response observed prior to denervation. In both cases, the responses were observed to be independent of the vaginal or hypothalamic temperatures.

We conclude that the present data support our original hypothesis [1] that the thermoregulatory responses to intra-abdominal heating result from stimulation of important thermoreceptors located in the abdominal viscera, probably in the walls of the rumen and intestine. Ipsilateral abolition of the response by unilateral splanchnotomy further supports our previous contention [1] that the responses were not a result of stimulation of spinal cord thermoreceptors. We also conclude from the present data that neural impulses from these intra-abdominal receptors are transmitted by way of the splanchnic nerves.

## References

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R. O. Rawson, Ph.D.
John B. Pierce Foundation
290 Congress Avenue
New Haven, Connecticut 06519, U.S.A.