EPIDIDYMAL AND TESTICULAR TEMPERATURE IN THE UNRESTRAINED CONSCIOUS RAT

D. E. BROOKS

*Department of Anatomy, Harvard Medical School,
Boston, Massachusetts 02115, U.S.A.*

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The testes of mammals which have a scrotum are maintained at a temperature several degrees below that of the abdomen; the mechanisms by which this temperature differential is maintained have recently been reviewed by Waites (1970). In contrast to the large amount of information concerning testicular temperature and its control, there have been no reported measurements of temperatures in the epididymis. The present work was carried out in order to measure epididymal temperature and to compare temperature control in this organ with that in the testis.

Thermocouples were made by joining iron and constantin wires (36 cm $\times$ 0.16 mm) end to end, the length of the junction being no longer than 2 mm. The wires were then coated with Teflon by American Durafilm Co., Inc., Newton Lower Falls, Massachusetts, U.S.A. The thermocouples were implanted in two male rats (strain CD from the Charles River Breeding Laboratories, Wilmington, Massachusetts, U.S.A.) each weighing 600 g. The animals were given 0.32 mg atropine sulphate intraperitoneally, followed 20 min later by 20 mg sodium pentobarbital. A mid-ventral abdominal incision was made and the testis and epididymis from one side were drawn into the abdominal cavity.

A 25-gauge needle (external diameter, 0.5 mm) was passed through each of the various organs to serve as a channel for the thermocouple lead; large blood vessels were avoided and no bleeding was evident. After passing the lead through the needle, the latter was removed and the lead was drawn through until the thermocouple was positioned inside the tissue. The wires were then bent flat against the surface of the organ, and as a further precaution to hold them in place, the two leads were held together with size 6–0 silk thread. The testis and epididymis were allowed to return to the scrotal cavity and an additional thermocouple was placed free in the abdominal cavity. The abdominal muscle wall was closed around the leads which were held in place at the point of exit by a suture to the muscle. The leads were then brought under the skin to appear at the back of the neck in the manner described for a permanent aortic intubation (Still & Whitcomb, 1956). The thermocouple leads were sufficiently flexible to allow free movement of the testis and epididymis between the scrotum and the abdominal cavity.

Recordings were taken from the animals on the day following the operation. The thermocouple leads were connected to a multipoint temperature recorder with an accuracy of $\pm 0.1^\circ\text{C}$ (Speedomax type G from Leeds and Northrup

TEXT-FIG. 1. Temperature recordings of the abdominal cavity (body), testis, caput epididymidis and cauda epididymidis in unrestrained conscious rats in an air temperature of 24° C. (a) Right testis and epididymis of Animal A; (b) left testis and epididymis of Animal B; (c) Animal A was transferred to an air temperature of 37° C for the period shown by the black bar; (d) Animal A was transferred to an air temperature of 5° C for the period shown by the black bar; (e) ethylene dichloride was briefly sprayed on the scrotum of Animal B at the point indicated by the arrow.

Co., North Wales, Pennsylvania, U.S.A.); the contacts between the recorder leads and the thermocouple leads were of identical metals to avoid thermoelectric effects. When recordings had been completed, the animals were killed, the scrotum was opened and the correct positioning of the thermocouples was confirmed.

By using this procedure, temperature recordings could be made on an animal which was not only conscious but also free to move about its cage. The recordings in Text-figs 1(a) and (b) show portions of tracings from two animals which had thermocouples in the right and left testis and epididymis, respectively. The temperature of the testis was maintained at 3 to 4° C below body temperature (in agreement with the measurements of Kormano, 1967a), the caput epididymidis was up to 1° C warmer than the testis whilst the cauda epididymidis was maintained at 3 to 4° C below testis temperature. These differences in temperature between different segments of the epididymis reflect the differences in blood flow measured by Setchell, Waites & Till (1964) and Waites & Setchell (1966). The temperature of the testis and epididymis was altered by the posture of the animal, the cauda epididymidis being subject to the greatest fluctuation. Presumably, this temperature variation was due in part to the movement of the testis and epididymis between the scrotum and abdominal cavity and in part to an alteration in the scrotal area available for evaporative cooling (when, for instance, the animal sat on its scrotum).

When placed in an air temperature of 37° C, the animals could not maintain the normal temperature differential between the body and the reproductive tract (Text-fig. 1c); they appeared uncomfortable and showed a marked rise in body temperature. When returned to 24° C, recovery of normal temperatures took approximately 45 min. The animals were less disturbed when placed in an air temperature of 5° C (Text-fig. 1d); however, while they were able to maintain their body temperature at a more constant level, the temperature differential between the body and the reproductive tract increased considerably. In contrast with the slow fall in temperature of the reproductive tract as a result of placing the animal in a cold environment, local cooling of the scrotum caused an immediate fall in temperature (Text-fig. 1e); recovery of normal temperatures was nevertheless protracted over about 30 min. Similar tracings were obtained from both animals under all of the experimental conditions described above.

This study has shown that there is a temperature differential maintained not only between the testis and the body in the rat, but also between the testis and the epididymis, and that the magnitude of these differentials is influenced by posture and environmental temperature. It is known that the temperature of the rat testis is largely controlled by scrotal factors (Kormano, 1967b) and it seems reasonable to assume that the temperature of the epididymis is controlled in a similar manner. The results indicate that on leaving the testis, spermatozoa are subjected to an increase in temperature in the caput epididymidis followed by a lower temperature in the cauda epididymidis. Whether these temperature changes are important for the process of sperm maturation in the epididymis, as testis temperature is important for spermatogenesis, remains to be investigated. In addition to the epididymal function concerned with sperm maturation, the

cauda epididymidis serves to store mature spermatozoa; the low temperature of this region may contribute to the longevity of spermatozoa contained within this part of the organ.

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REFERENCES

- KORMANO, M. (1967a) Development of the rectum-testis temperature difference in the post-natal rat. *J. Reprod. Fert.* **14**, 427.
- KORMANO, M. (1967b) Effect of circulatory disturbance of the testis on the rectum-testis difference in the rat. *Acta physiol. scand.* **69**, 209.
- SETCHELL, B. P., WAITES, G. M. H. & TILL, A. R. (1964) Variations in flow of blood within the epididymis and testis of the sheep and rat. *Nature, Lond.* **203**, 317.
- STILL, J. W. & WHITCOMB, E. (1956) Technique for permanent long-term intubation of rat aorta. *J. Lab. clin. Med.* **48**, 152.
- WAITES, G. M. H. (1970) *Temperature regulation and the testis*. In: The Testis, Vol. 1, p. 241. Eds. A. D. Johnson, W. R. Gomes and N. L. VanDemark. Academic Press, New York.
- WAITES, G. M. H. & SETCHELL, B. P. (1966) Changes in blood flow and vascular permeability of the testis, epididymis and accessory reproductive organs of the rat after the administration of cadmium chloride. *J. Endocr.* **34**, 329.