EFFECT OF TEMPERATURE AND SKIN FOLD ON BLOOD FLOW IN THE SCROTAL SKIN OF MERINO RAMS

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Summary

A technique for cannulating the external spermatic artery was developed and used, together with Krypton-85 clearance, to show that there are two compartments of blood flow (the fast and the slow) in the one region of scrotal skin of Merino rams selected for (Folds Plus) and against (Folds Minus) skin fold. The rate of blood flow of the fast compartment was seven to eight times faster than that of the slow. When the scrotum was heated the fast compartment increased markedly in size, the rate of blood flow (ml/100g tissue/min) of this compartment remaining unchanged. As a result of the increase in the size of the fast compartment relative to the slow compartment, mean scrotal blood flow also increased. The mean scrotal blood flows of Folds Plus and Folds Minus rams were similar.

I. INTRODUCTION

Merino rams selected for a low level of skin folding (Folds Minus) are less susceptible to infertility induced by heat than rams selected for a high level of skin folding (Folds Plus) (Fowler and Dun 1966). This is due mainly to the ability of Folds Minus rams to keep their testes cooler than the Folds Plus rams (Fowler 1967). The scrotum is largely responsible for controlling the amount of heat reaching the testes and it has been shown that the scrotal skin is more effective in thermoregulation in Folds Minus than in Folds Plus rams (Fowler 1966, 1967).

Cutaneous blood flow is thought to be an important thermoregulatory mechanism. A study of blood flow in the scrotal skin was, therefore, made to gain a fuller understanding of the nature of fertility differences between Folds Plus and Folds Minus rams and to observe blood flow in skins with different thermoregulatory attributes. A technique for cannulating the external spermatic artery was developed and is described.

II. MATERIALS AND METHODS

A polyvinylchloride catheter was inserted into a side branch of the external spermatic artery of five Folds Minus and four Folds Plus rams. The external spermatic artery at the site of cannulation lies in fat beneath the superficial inguinal lymph node. The node and fat were gently manipulated to expose the main artery (2 mm in diameter) at this site. A suitable side branch was located (1 mm diameter) into which the catheter was inserted so that its tip was level with the junction of the main artery and the side branch. The catheter was brought subcutaneously to a position on the rump and flushed daily with 0.5 ml of heparinized saline (3000 I.U./ml).

For the measurement of scrotal blood flow, each ram was supported in a canvas sling and the scrotum and testes were enclosed in a chamber similar to that described by Waites and Voglmayr (1963). The chamber was used to control the

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temperature of the scrotum at about $33.5^\circ$C or $37.5^\circ$C. Scrotal temperatures were measured with the aid of a thermocouple mounted in the tip of a 22 s.w.g. hypodermic needle. One thermocouple was inserted beneath the scrotal skin overlying the medial posterior surface of each testis. The thermocouples were connected to a potentiometric recorder with 1 mV full scale deflection, and were read once per minute. Four hundred to eight hundred microcuries of $^{85}$Kr in 0.5 to 1.0 ml of physiological saline were injected via the catheter into the external spermatic artery. The dose was flushed in with 0.5 ml of warmed saline. The rate at which radioactivity disappeared from the scrotal skin was monitored by a scintillation probe supported by the scrotal chamber about 5 cm from the scrotal skin overlying the testes. The output from the probe was fed into a linear ratemeter and a potentiometric recorder.

The clearance of $^{85}$Kr from the scrotal skin when expressed against time on semilogarithmic graph paper can be analysed into two single exponentials (Figure 1) (Riggs 1963). The rates of blood flow ($F'$ and $F''$) can be calculated from each exponential from the following equation (Herd et al. 1962):

$$F = \frac{0.693}{t^{1/2}}$$

where $F$ = blood flow ml/100 g tissue/min

$t^{1/2}$ = the half time of the exponential, $t'^{1/2}$ for $F'$ and $t''^{1/2}$ for $F''$

and $\lambda$ = the partition coefficient between tissue and blood i.e. the ratio of the concentration of $^{85}$Kr per unit weight of tissue to the concentration of isotope per unit volume of blood.

Calculations of scrotal blood flow were made with the knowledge that recirculation of $^{85}$Kr is small (Chidsey et al. 1959), that its equilibration between blood and tissue is rapid (Kety 1951), and on the assumption that $\lambda = 1.0$ (Jones 1950).

Each exponential is indicative of the rate of blood flow in a compartment, and the initial distribution of radioactivity ($A_0'$ and $A_0''$) to each compartment of blood flow can be determined by extrapolation of the two exponents to time zero. The relative sizes ($m'\%$ and $m''\%$) of the two compartments as a percentage of the total tissue mass were then estimated from the following equation (Casey and Thorburn 1965),

$$A_0'/A_0'' = \frac{F'm'/F''m''}{100}$$

$A_0'$ and $A_0''$ are thus the intercepts of the exponents at time zero for each compartment of blood flow.

Mean scrotal blood flow ($\bar{F}$) was calculated from the following equation (Casey and Thorburn 1965),

$$\bar{F} = \frac{F'm' + F''m''}{100}$$

Analyses of variance were used to examine the data, the arcsin transformation being used for percentages.

III. RESULTS

The scrotal skin of both types of rams showed a two compartment exponential curve for the clearance of $^{85}$Kr (Figure 1), the rate of blood flow for the fast compartment being seven to eight times greater than that of the slow compartment.
Folds Minus rams had a significantly higher \((P<0.05)\) blood flow to the "fast" compartment than Folds Plus rams, but blood flow to the slow compartment, mean scrotal blood flow and the size of the fast compartment were not significantly different. When the temperature of the scrotum was raised from 33.6°C to 37.5°C, the fast compartment increased in size by about 90% \((P<0.005)\) but rate of blood flow did not increase. There were significant increases in slow compartment blood flow \((P<0.05)\) and mean scrotal blood flow \((P<0.05)\) (Table 1).

IV. DISCUSSION

Scrotal skin of rams, like rabbit skin (Thorburn, Casey and Molyneux 1966), has a bimodal curve for \(^{85}\)Kr clearance, one exponential associated with the fast compartment, the other with the slow compartment. In rabbit skin, the fast compartment is represented by the capillary plexus surrounding the hair follicle and the slow compartment is believed to be associated with capillary blood flow in the rest of the skin. In the rabbit ear, where hair growth is sparse, the fast compartment is considerably smaller than for thigh skin where hair growth is much denser.
TABLE 1

The effect of heating on scrotal blood flow and compartment size

<table>
<thead>
<tr>
<th>Scrotal temperature °C</th>
<th>Scrotal blood flow ml/100g tissue/min</th>
<th>Relative size of fast compartment %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fast compartment F'</td>
<td>Slow compartment F''</td>
</tr>
<tr>
<td>Folds Plus rams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.5</td>
<td>17.41</td>
<td>2.23</td>
</tr>
<tr>
<td>37.5</td>
<td>17.55</td>
<td>2.95</td>
</tr>
<tr>
<td>Folds Minus rams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.5</td>
<td>21.33</td>
<td>2.38</td>
</tr>
<tr>
<td>37.5</td>
<td>20.97</td>
<td>2.83</td>
</tr>
</tbody>
</table>

Source of variation df†

<table>
<thead>
<tr>
<th></th>
<th>Variance and Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fold flock (F)</td>
<td>1</td>
</tr>
<tr>
<td>Scrotal temp (T)</td>
<td>1</td>
</tr>
<tr>
<td>F x I</td>
<td>1</td>
</tr>
<tr>
<td>Error</td>
<td>27</td>
</tr>
</tbody>
</table>

†df—degrees of freedom

Scrotal skin is also characterized by a relatively low follicle density and a small fast compartment, and the two compartments of the clearance curve may have functions similar to the corresponding compartments for rabbit skin.

The increase in blood flow that occurred when the scrotum was heated from 33.5°C to 37.5°C was partly due to an increase in the rate of blood flow of the slow compartment but more particularly to an increase in size of the fast compartment. The increase in size occurred too rapidly to be accounted for by the development of new capillaries and a plausible hypothesis is the opening of previously closed capillaries. Such an occurrence is not uncommon. In the resting muscles of frogs and guinea pigs, most of the capillaries are closed to the passage of blood whereas, in spontaneously contracting muscles, a large number of capillaries are opened (Krogh 1919).

The hair follicle in sheep is surrounded by a capillary plexus (Ryder 1955). Apocrine sweat glands are also known to have capillaries on their surface (Goodall and Yang 1954). Either or both the follicle and the sweat gland may respond to scrotal heating by a marked increase in vasculature. This increase may be associated mainly with increased metabolic demands of the heat activated scrotal sweat glands but histological evidence is needed to support this suggestion.

At scrotal temperatures of about 37.5°C, folds Plus rams are known to have lower scrotal sweating rates than Folds Minus rams (Fowler 1967). That this difference occurs in the absence of a difference in scrotal blood flow may be due to the fact that during moderate sweating, fluctuations in sweating rate can occur independently of blood flow (Kuno 1956). At higher scrotal temperatures of about 40.0°C, Folds Minus rams have a much greater mean scrotal blood flow and sweat loss than Folds Plus rams (Fowler 1967) and further studies with $^{85}$Kr at scrotal temperatures of 40°C are desirable.
V. ACKNOWLEDGMENTS

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VI. REFERENCES


