Ovarian blood flow in conscious and anaesthetized pregnant rabbits near term and the influence of arterial blood gas tensions

N. W. Bruce* and C. P. Gibbs†

Nuffield Institute for Medical Research, University of Oxford, Headley Way, Headington, Oxford OX3 9DS, U.K.

Summary. Total ovarian, luteal and stromal blood flows were measured with radioactive microspheres (25 μm diameter) in 7 rabbits anaesthetized with sodium pentobarbitone and 23 conscious rabbits at Day 28 of gestation. Despite major differences in cardiac output, arterial PO₂, PCO₂, pH and base status, ovarian tissue blood flows were similar in both groups. In the conscious rabbits total ovarian blood flow was negatively related to arterial pressure, and luteal blood flow was negatively related to pressure and arterial pH. In the anaesthetized rabbits ovarian stromal blood flow was positively related to arterial PO₂.

The rate of blood flow to the ovary of the pregnant and pseudopregnant rabbit has been shown to be high when measured with radioactive microspheres, mainly because the CL receive about 1000–4000 ml.min⁻¹.100 g⁻¹ (Abdul-Karim & Bruce, 1973; Novy & Cook, 1973; Janson & Albrecht, 1975). Little is known, however, of the control or function of these high flow rates or of the effects of anaesthesia on their measurement. We therefore compared ovarian blood flow rates in conscious and anaesthetized rabbits and examined the relationship of ovarian blood flow to blood pressure, cardiac output and arterial blood gas tensions which vary greatly in the conscious pregnant rabbit near term (Bruce & Gibbs, 1974).

The rabbits were of a predominantly New Zealand White strain and were mated at about 12.00 hours (Day 0 of gestation). Ovarian blood flows were measured with radioactive microspheres (25 μm diameter) on Day 28 of gestation: the technique used and the calculations made are given by Bruce & Abdul Karim (1973). Measurements were taken from 7 anaesthetized rabbits about 30–60 min after an intravenous injection of 35 mg sodium pentobarbitone/kg. The other 23 rabbits were anaesthetized on Day 27 to insert a ventricular and two femoral arterial cannulae in preparation for the blood flow measurements. About 24 hr later, the then conscious rabbit was placed in a closed wicker box and radioactive microspheres injected when the rabbit was resting. Arterial blood samples were taken immediately before and after the injection for blood gas analysis (Radiometer, Copenhagen) and the mean of the two values used in the results (Table 1). The blood samples were collected in glass syringes and kept in an ice bucket for no longer than 30 min before analysis.

Many of the conscious rabbits, although quiet, were hyperventilating at the time of microsphere injection. This may well have been due to anxiety and disturbance of their catecholamine levels. Their mean cardiac output, arterial PO₂ and base deficit were respectively 51, 24 and 179 % higher than those of the anaesthetized rabbits whilst the arterial PCO₂ was 31 % lower. Despite these major differences in physiological status, the mean total ovarian, luteal and ovarian stromal blood flow rates were remarkably similar in both groups. This agrees with the findings of Mattner, Stacy & Brown (1975) that the velocity of blood in the ovarian artery of conscious sheep is little changed by sodium pentobarbitone anaesthesia.

* Present address: Department of Anatomy and Human Biology, University of Western Australia, Nedlands, Western Australia 6009, Australia.

† Present address: Department of Anesthesiology, University of Florida—College of Medicine, Gainesville, Florida 32610, U.S.A.
Table 1. Mean (±S.E.M.) ovarian weights and blood flows in conscious and anaesthetized rabbits at Day 28 of pregnancy

<table>
<thead>
<tr>
<th></th>
<th>Conscious</th>
<th>Anaesthetized</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of rabbits</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>Maternal weight (g)</td>
<td>3566 ± 106</td>
<td>3523 ± 143</td>
</tr>
<tr>
<td>Cardiac output (ml.min⁻¹.kg⁻¹)</td>
<td>194 ± 12.9</td>
<td>128 ± 9.4*</td>
</tr>
<tr>
<td>Arterial pressure (mmHg)</td>
<td>77 ± 2.5</td>
<td>84 ± 7.3</td>
</tr>
<tr>
<td>Arterial P O₂ (mmHg)</td>
<td>104 ± 3.0</td>
<td>84 ± 4.5**</td>
</tr>
<tr>
<td>Arterial PCO₂ (mmHg)</td>
<td>22.5 ± 1.3</td>
<td>32.5 ± 2.7**</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>7.42 ± 0.01</td>
<td>7.41 ± 0.03</td>
</tr>
<tr>
<td>Arterial base deficit (mequiv/l)</td>
<td>8.36 ± 1.12</td>
<td>3.00 ± 2.14*</td>
</tr>
</tbody>
</table>

Ovary

- Weight (g): 0.533 ± 0.05 vs. 0.464 ± 0.032
- Blood flow (ml/min): 2.026 ± 0.219 vs. 2.129 ± 0.217
- Blood flow (ml.min⁻¹.100 g⁻¹): 392 ± 30 vs. 459 ± 42

Corpora lutea (per ovary)

- Number: 5.33 ± 0.25 vs. 5.28 ± 0.30
- Weight (g): 0.112 ± 0.006 vs. 0.140 ± 0.011
- Blood flow (ml.min⁻¹.100 g⁻¹): 1384 ± 152 vs. 1325 ± 183

Stromal tissue (per ovary)

- Weight (g): 0.462 ± 0.044 vs. 0.325 ± 0.042
- Blood flow (ml.min⁻¹.100 g⁻¹): 123 ± 13 vs. 116 ± 8

Values significantly different from those in conscious rabbits, *P < 0.05, **P < 0.01 (unpaired t test).

Linear regression and correlation analyses were carried out separately for ovarian total, luteal and stromal blood flows on blood pressure, cardiac output and arterial P O₂, P CO₂, pH and base deficits of the two groups. In the conscious rabbits total ovarian blood flow was negatively related to pressure: ovarian flow (ml.min⁻¹.100 g⁻¹) = 1016 - 8.11 (pressure, mmHg); r = -0.670; P < 0.001. Luteal blood flow in the conscious rabbits was negatively related to pressure and to arterial pH: CL flow (ml.min⁻¹.100 g⁻¹) = 3390 - 26.05 (pressure, mmHg); r = -0.425; P < 0.05; and CL flow (ml.min⁻¹.100 g⁻¹) = 56,100 - 7370 (arterial pH); r = -0.567; P < 0.01. No other significant relationship was evident in the conscious rabbits. In the anaesthetized rabbits the only significant relationship was between ovarian stromal blood flow and arterial P O₂; stromal flow (ml.min⁻¹.100 g⁻¹) = -23.6 + 1.67 (arterial P O₂, mmHg); r = 0.931; P < 0.05 (N = 5 since two of the P O₂ measurements failed).

Janson & Albrecht (1975) found that ovarian blood flow in anaesthetized rabbits was positively related to arterial pressure and that the ovarian vascular resistance to blood flow was relatively constant. Since we found that ovarian flow was negatively related to pressure in the conscious animals, ovarian vascular resistance must have increased with pressure. Furthermore, the negative relationship between flow and pressure was independent of the rate of cardiac output (as shown by multiple regression analysis). Therefore the ovarian resistance to blood flow, as a proportion of the total body resistance, also increased with pressure. Whether ovarian vascular resistance in conscious rabbits is affected directly by the local arterial perfusion pressure or indirectly by general systemic factors, controlling or controlled by arterial pressure, is yet to be determined. Although arterial pressure in the conscious rabbits was not related to any of the other organ blood flows measured, the cardiac output, which was not related to any of the ovarian tissue blood flows, was significantly related to brain, heart, kidney, placental and myometrial blood flows (N. W. Bruce & C. P. Gibbs, unpublished).

The low arterio-venous difference in ovarian P O₂ in rabbits (Abdul-Karim & Bruce, 1973) and sheep (Baird, Giles & Cockburn, 1973) suggests that the high rate of ovarian blood flow is not merely to provide oxygen, although tissue P O₂ rather than rate of oxygen consumption might be critical to ovarian function (Bruce & Moor, 1975). In the conscious rabbits, which had high arterial P O₂...
levels (range 83–118 mmHg), none of the ovarian tissue blood flows was related to $PO_2$ whereas in the anaesthetized rabbits with lower $PO_2$ levels (range 60–95 mmHg) ovarian stromal blood flow was positively related to arterial $PO_2$.

While the present results show that ovarian tissue blood flows can be similar in anaesthetized and conscious, though probably excited, rabbits under widely different physiological conditions, they also show that the ovarian tissue vascular resistance to flow can be influenced by, or in common with, arterial pressure, blood pH and $PO_2$ levels.

We thank Professor G. S. Dawes for advice and encouragement and Mr A. Stevens and Mr H. Elvidge for technical assistance. This work was supported by grants from the Medical Research Council and the Nuffield Committee for the Advancement of Medicine.

References


Received 24 November 1975