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

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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 P_{O_2} , P_{CO_2} , 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 P_{O_2} .

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 $\text{ml. min}^{-1}. 100 \text{ g}^{-1}$ (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 P_{O_2} and base deficit were respectively 51, 24 and 179% higher than those of the anaesthetized rabbits whilst the arterial P_{CO_2} 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.

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Table 1. Mean ($\pm$ S.E.M.) ovarian weights and blood flows in conscious and anaesthetized rabbits at Day 28 of pregnancy

	Conscious	Anaesthetized
No. of rabbits	23	7
Maternal weight (g)	3566 $\pm$ 106	3523 $\pm$ 143
Cardiac output (ml.min ⁻¹ .kg ⁻¹)	194 $\pm$ 12.9	128 $\pm$ 9.4*
Arterial pressure (mmHg)	77 $\pm$ 2.5	84 $\pm$ 7.3
Arterial P_{O_2} (mmHg)	104 $\pm$ 3.0	84 $\pm$ 4.5**
Arterial P_{CO_2} (mmHg)	22.5 $\pm$ 1.3	32.5 $\pm$ 2.7**
Arterial pH	7.42 $\pm$ 0.01	7.41 $\pm$ 0.03
Arterial base deficit (mequiv/l)	8.36 $\pm$ 1.12	3.00 $\pm$ 2.14*
Ovary		
Weight (g)	0.533 $\pm$ 0.05	0.464 $\pm$ 0.032
Blood flow (ml/min)	2.026 $\pm$ 0.219	2.129 $\pm$ 0.217
Blood flow (ml.min ⁻¹ .100 g ⁻¹)	392 $\pm$ 30	459 $\pm$ 42
Corpora lutea (per ovary)		
Number	5.33 $\pm$ 0.25	5.28 $\pm$ 0.30
Weight (g)	0.112 $\pm$ 0.006	0.140 $\pm$ 0.011
Blood flow (ml.min ⁻¹ .100 g ⁻¹)	1384 $\pm$ 152	1325 $\pm$ 183
Stromal tissue (per ovary)		
Weight (g)	0.462 $\pm$ 0.044	0.325 $\pm$ 0.042
Blood flow (ml.min ⁻¹ .100 g ⁻¹)	123 $\pm$ 13	116 $\pm$ 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_{O_2} , P_{CO_2} , 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_{O_2} : stromal flow (ml.min⁻¹.100 g⁻¹) = -23.6 + 1.67 (arterial P_{O_2} , mmHg); $r = 0.931$; $P < 0.05$ ($N = 5$ since two of the P_{O_2} 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_{O_2} 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_{O_2} rather than rate of oxygen consumption might be critical to ovarian function (Bruce & Moor, 1975). In the conscious rabbits, which had high arterial P_{O_2}

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.

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