BRIEF COMMUNICATION

Effects of milk stasis and feed withdrawal on capillary exchange capacity in the goat mammary gland

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Keywords : capillary exchange capacity; mammary gland; milk stasis; feed withdrawal.

The lactating mammary gland is critically dependent upon the provision of nutrients and hormonal stimuli from the blood to sustain milk synthesis. This is reflected in the high correlation between mammary arterial blood flow (F) and milk yield (MY). During established lactation in goats, frequent milking with oxytocin results in a higher blood flow to the mammary gland (Prosser and Davis, 1992). Conversely, MY and F decrease during both milk stasis (Stelwagen et al. 1994) and feed withdrawal (Davis and Collier, 1985). It has yet to be determined whether these decreases in the blood supply cause the decreases in MY or are as a result of a decrease in demand for blood by the secretory tissue.

The purpose of the present study was to investigate the behaviour of the microvasculature in the mammary gland of lactating goats following milk stasis (MS) and feed withdrawal (FW). The capillary exchange capacity within the mammary gland was measured using the dual indicator dilution technique. This study was undertaken with the approval of the Ruakura Animal Ethics Committee (Hamilton, New Zealand).

Four lactating Saanen goats were surgically prepared with an ultrasonic blood flow probe (Transonics Systems Inc., Ithaca, NY, USA) around the pudic artery and an indwelling arterial catheter. Surgery was performed at least one week before experimentation. The mammary vein was catheterised the day before measurements were made. Treatments consisted of : control (C), twice-daily milked animals, fed on hay (ad libitum) and concentrates (2 kg, twice daily); after 18 to 20h milk stasis (MS); and after 26 to 28h of feed withdrawal (FW).

The dual indicator dilution technique involved a single injection of a mixture of two indicators into the pudic artery, while continuously sampling the venous outflow from the gland for up to 2 min after the injection. The two indicators employed were: the non diffusible FITC-albumin (Sigma Chemical Co., St Louis, MO, USA), which remains in the circulation; and ^{14}C-sucrose (Amersham Laboratories, Buckinghamshire, UK) which is freely diffusible across the capillary endothelium. Extraction (E) of the diffusible indicator, ^{14}C-sucrose, was calculated from the difference in concentrations of the two indicators in the venous outflow from the gland up to 10 seconds after injection. Tissue weight was estimated from milk production as described by Linzell, 1972.

The capillary exchange capacity is described by the equation: $PS = -F \log_e(1-E)$, and is a product of the permeability (P) and surface area (S) of the capillaries (Shepherd, 1981). Integration of the area under the FITC-albumin concentration-time curve enabled the determination of the time taken for half the intravascular indicator to reach the venous outflow, the mean transit time (t).

Despite the limited number of animals (n = 4), results showed a significant decrease in both F and PS due to milk stasis and feed withdrawal (Table 1). Extraction of the freely diffusible indicator tended to be lower than control with MS treatment (P=0.1), whilst it was unchanged following FW (P=0.72). The significant increase in t follow-

TABLE 1: Effect of milk stasis and feed withdrawal on the mammary arterial flow (F), mean transit time of the intravascular indicator (t), extraction ratio (E) and the capillary exchange capacity – the capillary permeability – surface area product (PS). Each value represents the mean ± SEM of four animals.

	Control	Milk Stasis	Feed Withdrawal
Mammary Arterial Flow (F) ml/min/100g tissue	40.40 ± 8.58[a]	14.98 ± 2.07[b]	12.00 ± 3.28[b]
Mean Transit time (t)(sec)	12.08 ± 1.03[a]	12.95 ± 1.08[a]	22.25 ± 3.68[b]
Extraction (E)	0.70 ± 0.04	0.48 ± 0.08	0.67 ± 0.07
Permeability x Surface Area (PS) ml/min/100 g tissue	47.91 ± 8.98[a]	9.47 ± 1.42[b]	12.18 ± 2.30[b]

[a, b] means within the same row with different superscripts differ significantly ($p<.05$)

ing FW is consistent with a lower capillary flow in the gland and a similar number of capillaries being perfused. Therefore, the decrease in PS would be due to a decrease in the permeability of the capillaries, with S being at least the same or greater than control during this physiological state.

The lack of change in E could be explained by the longer residence time within the capillaries allowing more efficient extraction of the diffusible indicator even though P was reduced. With MS, despite decreased arterial blood flow, t was not different to that with C, suggesting that a smaller number of capillaries were perfused, and hence the decrease in PS with this treatment may be predicted to be due to a fall in S. Since S is largely a reflection of the number of capillaries available for perfusion, it might be surmised that milk stasis results in closure of capillaries within the mammary gland. Silver (1956), also found evidence of capillary derecruitment during milk stasis, suggesting that the mammary gland is capable of controlling the delivery of substrates to its secretory cells, probably by changes in the balance of locally produced vasoactive compounds. In contrast, when nutrition is limiting, the apparent decrease in capillary permeability may be due to systemic control of the microvasculature, an aspect which requires further investigation.

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