Measurement of pelvic blood flow changes in response to posture in normal subjects and in women with pelvic pain owing to congestion by using a thermal technique

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1. A method is described for studying pelvic blood flow in women by the indirect method of measuring vaginal temperature changes in response to a posture change. Ten women with chronic pelvic pain and venous congestion and 10 normal subjects were observed during posture changes over a 2 h period.
2. Vaginal temperature minus axillary temperature rose after subjects changed from the supine to the seated position, indicating a fall in the rate of pelvic blood flow.
3. A significantly greater variance in the rate of change in vaginal temperature minus axillary temperature was found in patients with pelvic venous congestion compared with control subjects \( P<0.005 \).
4. The findings are consistent with a disorder of blood flow regulation in women with pelvic pain owing to congestion.

INTRODUCTION

The understanding of circulatory control mechanisms in the pelvic organs in women is hampered by difficulties in measuring blood flow quantitatively. The uterine circulation can be studied by using Doppler ultrasound \[1\], but in non-pregnant women the small diameter and tortuosity of the uterine and ovarian arteries prevent accurate and reproducible studies by this method \[2\]. Uterine \[3, 4\] and ovarian \[5\] blood flow may be studied using xenon clearance, but this is not an attractive technique, being complex and involving the use of a radioactive isotope.

We report the development of a relatively non-invasive thermal method of investigating blood flow changes, which is suitable for continuous observation. We used as a model posture changes in normal women and in women with pelvic venous congestion. The method is based on the observation in sheep that uterine blood flow can be quantified indirectly by measuring changes in uterine temperature \[8\]. Furthermore, temperature sensitivity to flow in the vagina of sheep was approximately 70% of that found in the uterus \[9\]. In the present study, vaginal temperature measurements in women were used to determine relative changes in blood flow with posture in normal subjects and in women with pelvic pain owing to congestion.

METHODS

The temperature of an organ depends on the balance of metabolic heat production and dissipation of heat by the circulation. Heat transfer varies with the temperature of blood entering the organ and with the rate of blood flow. This relationship was demonstrated in a mouse model by applying heat to a tumour, varying the blood supply, and monitoring the resultant change in temperature \[10\]. Over a short observation period it is reasonable to assume constant metabolic heat production, but interpretation of vaginal temperature changes in terms of blood flow must be corrected for possible changes in core temperature. Core temperature is known to be affected by changes in posture \[11\]. Axillary temperature may be used as a measure of core temperature \[12\]. It correlated well with pulmonary artery temperature in a clinical context \[13\], and it has the practical advantage of being non-invasive.

An axillary temperature probe was manufactured by mounting a thermistor and a twisted pair cable in a 20cm length of 8-gauge Ryle's tube. The thermistor end of the tube was sealed with Perspex cement and the cable led to a two-way connector used to connect the probe to an amplifier once the probe had been inserted. This probe was connected...
A vaginal temperature probe suitable for glutaraldehyde sterilization was designed for self-insertion to provide maximum acceptability to subjects. The main body of the probe was manufactured from Plastazote closed cell cross-linked low-density polyethylene foam (BXL Plastics Ltd, Croydon, Surrey, U.K.). Four thermistors were mounted at quadrants close to the tip of the probe, with a 50 cm length of fine 8-way cable to a connector (Fig. 1). This cable also provided a convenient means of recovering the probe after each recording session. The probe was sealed by stretching a condom over the main body, tying it off around the cable exit, and dipping the complete assembly up to the connector in latex (Revultex; Bellman Carter Ltd, Raynes Park, London, U.K.). The temperature measured by the four thermistors was averaged to reduce the possible effect of differing degrees of engorgement at different locations within the vagina [14]. The amplifiers for both the vaginal and axillary probes were calibrated to produce an output of 1 V/°C over the range 36–38°C, giving a resolution of 0.002°C. Temperature readings from both probes were recorded at 30 s intervals and were stored on a portable four-channel data logger (Rustrak Quartel; Gulton Ltd, Hove, Sussex, U.K.) before uploading into a microcomputer for data analysis and storage.

Ten women with chronic pelvic pain who had normal findings at laparoscopy and venographically demonstrated venous congestion were recruited for the study together with 10 subjects who had no pain. All women were within the reproductive age group and were not taking anti-hypertensive medication. Three women in each group were taking the combined oral contraceptive pill.

RESULTS

The mean age of the control subjects was 28 years compared with 31 years in the group with pelvic pain (95% confidence interval for the difference in means, -1.02 to 7.30). Three out of ten control subjects were nulliparous compared with five out of ten in the group with pelvic pain (95% confidence interval for the difference in proportions, -0.62 to 0.22). Mean body mass index (weight/height²) was 23 and 22 kg/m² in the control subjects and the group with pelvic congestion, respectively. Three subjects in each group were taking the oral contraceptive pill. In those not taking the contraceptive pill the median day of the menstrual cycle for the patients with pelvic pain was 20 and for control subjects it was 24 (not significant). Two of the group with pelvic pain and one control subject had a spontaneous cycle length of greater than 35 days. Four out of seven patients with pelvic pain and five out of seven control subjects were within 14 days of their natural cycle length, i.e. in the luteal phase.

Vaginal temperature fell while the subject was in the supine position, and rose after she assumed the sitting position in 16 of the 20 subjects. The mean (SD) change in vaginal temperature was 0.091°C (0.05°C) in control subjects and 0.072°C (0.031°C) in patients with pelvic pain. Similar changes in axillary temperature were observed in 12 of the 20 subjects, with a mean (SD) of 0.057°C (0.041°C) in control subjects and of 0.089°C (0.027°C) in patients with pelvic pain. The difference between vaginal and axillary temperature (AT) for each subject was plotted against time (Figs. 2 and 3). Adopting the supine position was followed by a fall in ΔT to a steady state at 35 min. Changing posture from lying to sitting led to a rise in ΔT. The pattern of change appeared to be more erratic in patients with pelvic congestion than in normal subjects.

Linear regression analysis was used to study the
rate of change in $\Delta T$ for the 10 min period after the posture change from supine to sitting. The mean, SD and variance of the slopes for the two groups were calculated. The slopes and variances for each group did not deviate significantly from the normal distribution. Although there was no significant difference between the mean slope for the control group ($2.46 \times 10^{-3} ^\circ C/min$, SD $3.31 \times 10^{-3} ^\circ C/min$) and that for the group with pelvic congestion ($3.07 \times 10^{-3} ^\circ C/min$, SD $8.45 \times 10^{-3} ^\circ C/min$), the variance of these slopes was significantly greater in the group with pelvic congestion ($F_{9,9} = 6.52$, $P < 0.005$).

**DISCUSSION**

Although it is not possible to quantify changes in the rate of pelvic blood flow using measured changes in temperature, the method described can give an indication of relative changes in flow. Our studies showed a rise in $\Delta T$, indicating a fall in
blood flow, during the first 20 min after changing from the supine to the sitting position. $\Delta T$ then reached a plateau. This could be caused by gravity reducing venous return, which is then compensated for by the physiological response of venoconstriction.

The uterine and ovarian circulation is, like the splanchnic bed, characterized by the absence of tissue supports and valves. Venous return is likely to be dependent on the pumping effects of uterine contractions and, most importantly, on venous contractility. Spontaneous contractility of pelvic veins has been observed in vitro [16, 17] and in vivo [18] and is likely to be under autonomic nervous as well as local regulation by mechanisms not yet well understood.

The results show a significant difference in the variance of the rate of change in corrected temperature ($\Delta T$) after a change in posture between control subjects and women with pelvic congestion. The smaller variance in control subjects suggests tighter control over the circulatory response to the stimulus of a posture change compared with the group with pelvic congestion, who exhibit pooling of blood in dilated pelvic veins. These observations provide evidence further to that obtained by venography [6], ultrasonography [18] and applied potential tomography [19] for a vascular disorder in women with chronic pelvic pain.

Pelvic congestion is a condition of the reproductive years, which usually resolves at the menopause. However, further studies are required to establish whether it is a consequence of ovarian dysfunction, or whether abnormalities of neural or endothelial circulatory control mechanisms [20] or the effects of a humoral agent, such as atrial natriuretic peptide [21, 22], are responsible.

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REFERENCES