

EFFECTS OF ACTIVITY, ALCOHOL, SMOKING, AND THE MENSTRUAL CYCLE ON LIQUID CRYSTAL BREAST THERMOGRAPHY¹

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ABSTRACT

This study is part of a continuing program to evaluate the efficacy and reliability of liquid-crystal thermography in breast-cancer detection. The purpose was to evaluate any possible effect(s) of daily activity, smoking, alcohol consumption, amount of sleep, and the menstrual cycle on the liquid-crystal thermographic breast-pattern. Ten apparently healthy women served as subjects and were examined by liquid-crystal thermography every day for 28 (minimum) to 45 (maximum) consecutive days for thermogram changes. The results indicate that daily activity and the menstrual cycle should not affect the reliability of liquid-crystal thermogram interpretation in breast-cancer studies. Alcohol consumption and cigarette smoking prior to liquid-crystal thermographic examination could change the normal pattern to an extent that reliable interpretation might not be possible. There appears to be a thermographic-pattern change closely associated with the probable time of ovulation.

INTRODUCTION

Thermography is a generic term applied to techniques employed to map surface-temperature patterns. A thermographic technique should provide a quantitative, instantaneous thermogram equivalent to the largest possible number of individual temperature measurements per unit area, with a high degree of temperature sensitivity and optical resolution. Cholesteric liquid-crystals are esters of cholesterol which have a high thermal sensitivity. When applied to a blackened surface, these materials give rise to iridescent colors, the dominant wavelength being influenced by a very small temperature change. Liquid-crystal thermography is capable of producing a color thermogram over a large area with a temperature sensitivity of 0.1°C and a spatial resolution of 1000 lines per inch (Ferguson, 1968). We have developed a thermographic technique which utilizes color-temperature-sensitive cholesteric liquid-crystals.

Liquid-crystal thermographic examination of 197 apparently healthy women with no known breast abnormalities was undertaken to classify normal patterns (Davison *et al.*, 1972). Pattern-type distribution was studied as a function of age, past pregnancies, previous lactation, and breast size. Similarities among breast thermograms allowed classification of patterns into six distinct groups, with subgroup categorization within three vascular groups. Results from another portion of the study, based on the examination of 105 women with breast characteristics that indicated the possible presence of a malignancy, compared favorably with established thermographic and mammographic techniques. Our success is attributed to the excellent spatial resolution and temperature sensitivity of liquid-crystal thermography.

This study is part of a continuing program at Kent State to evaluate the efficacy and reliability of liquid-crystal thermography in early detection and mass screening for breast cancer. Possible effects of the menstrual cycle, contraceptives, and pregnancy on the breast thermal-pattern have been studied by several investigators (Gershon-Cohen, *et al.*, 1964; Isard and Shilo, 1968; Draper and Jones, 1969; Isard, *et al.*, 1969). These investigators, using infra-red thermography, have noted a changing thermal pattern during the menstrual cycle. They are in agreement that slight changes from day to day during the cycle should have no significant effect in breast-cancer detection using the infra-red thermographic technique.

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The purpose of the present study was to evaluate any effect(s) of the menstrual cycle on the liquid-crystal thermographic pattern relative to breast-cancer detection. In addition to possible cyclic effect, other variables—daily activity, alcohol consumption, cigarette smoking, and the amount of sleep—were included which might possibly affect the breast thermal-pattern.

THERMOGRAPHIC TECHNIQUE

The color-temperature response of liquid crystals utilized for breast thermography is within a 3°C temperature range. Liquid crystals covering the temperature ranges of 30–32°C, 31–33°C, 32–34°C, 33–35°C, and 34–36°C are most frequently used for breast thermography. The coldest temperature of the range is red, the warmest temperature is blue, and the intermediate temperature is green. The specific range of each material was developed by varying the quantities of cholesteryl nonanoate, cholesteryl oleylcarbonate, and cholesteryl benzoate (Davison, *et al.*, 1972). The color-temperature response of each material was calibrated by photometric methods (Ferguson, 1968; Davison, *et al.*, 1972).

The examination procedure used in this study is identical to that used by us in the past. The subjects were examined in the supine position, with hands resting comfortably behind the head, and with the entire surface of both breasts and the axilla exposed. The proper liquid-crystal color-temperature range was selected on the basis of a temperature-range estimation made with a skin-surface thermistor probe. A black-water base paint was sprayed on the breasts. Liquid crystals in five percent solution with petroleum ether were then sprayed over the dried, blackened surface. Evaporation of the petroleum ether left an even layer of liquid crystals which gave rise to a very sharp iridescent color-temperature pattern. A short equilibration time was necessary, due to the cooling effects of the spraying and to solvent evaporation. Equilibration was known to have been reached when the liquid crystals indicated no further temperature change on the thermogram. Three color photographs of each subject, a frontal and both lateral views, were made for permanent record.

DESIGN AND SUBJECTS

Subjects of this study were 10 apparently healthy women, who were examined daily for a period of from 28 (minimum) to 45 (maximum) consecutive days for thermogram changes. Subjects were examined at the same time each day. Weather conditions and room temperature were recorded prior to each examination. A record was made of each subject's medical history, with special regard to the breast and menstrual cycle. Each subject completed a daily questionnaire concerning the menstrual cycle, types of activity, alcohol consumption, drugs, amount of sleep, and cigarette usage. Additionally, each subject was asked to maintain a daily body-temperature chart.

Of the 10 women studied in this project, seven were very active college coeds (one of whom was taking an oral contraceptive), two were post-menopause women, and the other was a non-coed on an oral contraceptive regime.

RESULTS AND DISCUSSION

Liquid-crystal thermogram changes were observed in each woman studied. The most extensive and frequent breast thermal-changes were seen in the young, active coeds who experienced irregular sleeping, eating, and drinking habits. Only slight changes were noticed in the post-menopause women, who were relatively inactive and maintained regular daily schedules, and in the two taking an oral contraceptive.

Subjects under the influence of alcohol or experiencing a hangover exhibited

an overall increased temperature and a more diffuse thermal pattern than normal. This is expectable, due to the vasodilatory effects of alcohol.

Cigarettes were given to several women while on the examination table. At these times, a significant change in thermograph pattern was observed if the subject was either a non-smoker or an occasional smoker who had not smoked in the past 12 hours. In one case, a 3°C temperature decrease was observed over most of the breast surface while the subject was smoking.

In the six women with apparently normal menstrual cycles, the breasts were cold during menstruation and immediately thereafter, in comparison to a warm sternal area (in general, a 3°C difference). Until the time of expected ovulation, i.e., days 13 to 16, the breast temperature increased slowly, while the sternal temperature decreased. The warmest breast temperatures were recorded during the time of expected ovulation. Subsequent to this time, the breasts cooled, while the sternal temperature increased. The coldest breast temperatures were recorded during the menstrual period. In summary, excluding the menstrual period, the breast thermal-patterns were characterized by warm breasts with respect to a cool sternal area in what is considered the normal pre-ovulatory portion of the cycle, while the situation was reversed during the latter half of the cycle.

The cyclic changes in breast thermal-patterns of the six women described above were not apparent in either the two post-menopause subjects or the two women taking oral contraceptives. These changes, therefore, are apparently related directly to events associated with the menstrual cycle.

In three of the six active coeds with apparently regular menstrual cycles, a distinctly different thermographic pattern was observed near the midpoint of the cycle. This thermographic pattern most resembled a warm Group III (Spotted) or Group VI (Intense Vascular) (Davison, *et al.*, 1972). Results of the body-temperature charts maintained by the six women were inconclusive in establishing the ovulatory period. Therefore direct comparison of the breast thermal-pattern change with body temperature was not possible, and we can only assume that the normal, regular cyclic events were present. It is highly possible that the peculiar and dramatic change in thermal pattern was due to a factor, or factors, in the internal breast environment which accompanies the ovulatory process. This phenomenon may be of short duration, i.e., in terms of hours rather than days, thereby explaining our finding it in only three of the six subjects.

In a future project, we plan to study women on a normal cycle during the probable ovulatory period at shorter time intervals than in the present study (i.e., four hours between thermograms, rather than 24 hours). Additional tests, e.g., measurement of urinary pregnanediol, will also be included to afford a more comparative study.

SUMMARY

The daily changes that occur with normal activity and the menstrual cycle should not affect the reliability of breast liquid-crystal thermogram interpretations. Breast thermal-pattern changes observed in six women with apparently regular menstrual cycles were not observed in either two post-menopause subjects or two women taking oral contraceptives. Alcohol consumption and cigarette smoking prior to thermographic examination can change the normal thermogram to such an extent that a reliable interpretation is impossible. Inclusion of a liquid-crystal thermogram in the clinical history of a subject necessitates information concerning the prior activity level, smoking history, alcohol consumption, and time relative to the menstrual cycle. This information affords a basis for comparison with subsequent liquid-crystal thermograms and aids in definitive interpretation.

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