

Breast evaluation during lactation using thermography and pressure algometry

Avaliação da mama na lactação por termografia e presença de dor

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Keywords

Lactation disorders; Thermography; Pain measurement; Nursing diagnosis; Postpartum period

Descritores

Transtornos da lactação; Termografia; Medição da dor; Diagnóstico de enfermagem; Período pós-parto

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Abstract

Objective: To obtain scientific evidence of alterations in puerperal breast based on clinical examinations and pain measurements using pressure algometry and thermography.

Methods: This qualitative descriptive and experimental study examined six lactating women included in a Human Milk Bank. Using clinical examinations, pressure algometry, and thermography, data from puerperal mammary glands were collected. A descriptive analysis of the quantitative variables expressed as averages, minimal and maximal values, and standard deviations was conducted. Image analyses were performed using a ThermoCAM™ 2.9 (FLIR Systems, Inc.) software.

Results: Flaccid mammary glands were the coldest, with an average temperature of 32.7°C (SD±0.32386°C), and more tolerant to pain, with an average of 1.87 kgf/m² (SD ±0.29558 kgf/m²). The greater the degree of engorgement, the higher the temperature observed.

Conclusion: The results indicate that it is possible to use clinical examinations, pressure algometry, and infrared thermography to delineate patterns between various events affecting the mammary glands during lactation.

Resumo

Objetivo: Identificar evidências científicas das alterações na mama puerperal baseadas no exame clínico, na medição da dor por algometria de pressão e termografia.

Métodos: Estudo descritivo, experimental, de abordagem quali-quantitativa, realizado com seis lactantes em um Banco de Leite Humano. Por meio de exame clínico, algometria de pressão e termografia, foram coletados dados das mamas em fase puerperal. Efetuou-se a análise descritiva das variáveis quantitativas expressas por médias, valores mínimos, máximos e desvios-padrão.

Resultados: As mamas flácidas foram as mais frias com temperatura média de 32,7°C (DP±0,32386) e mais tolerantes à dor, com média de 1,87 kgf (DP±0,29558). Quanto maior a intensidade do ingurgitamento, maior foi a temperatura encontrada. A análise das imagens foram realizadas utilizando o *software Thermo CAM™ 2,9 (FLIR Systems, Inc.)*.

Conclusão: Os resultados indicam que, a partir do exame clínico, algometria de pressão e termografia infravermelha, foi possível delinear um padrão diferencial entre os vários eventos que acometem a mama no processo da lactação.

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Introduction

Although the advantages of breastfeeding have been under discussion,^(1,2) several factors lead to the interruption of early breastfeeding^(2,3) before a baby's sixth month of life,⁽⁴⁾ which negatively impacts the child's health.⁽¹⁾ Among the reasons for this interruption, breast infections and mammary engorgement (ME) are common problems faced by nursing mothers during lactation.⁽⁵⁾

The pathologies that affect puerperal mammary glands are less known than those affecting non-lactating breasts.⁽⁶⁾ Methods have been described to study breast anatomy^(6,7) and the physiology of lactation;⁽⁶⁾ however, studies on temperature and pain perception in lactating breasts are scarce.

Physical examination by inspection and palpation is one of the main techniques used to evaluate lactating breasts. Manual palpation, which allows for the examination of engorged mammary glands and the identification of the most affected quadrants, is used in clinical practice as an important physical examination.

The use of technological resources in health care increases daily and minimizes the effects of subjectivity, so common in manual palpation procedures,⁽³⁾ thus they are becoming popular and the main tool in medical-hospital intervention. Pressure algometry can be used to quantify pain perception for diagnostic, experimental, or forensic purposes. This technique measures an individual's nociceptive senses, quantifies their perception, and tests their pain tolerance evoked by physical stimuli. It also enables clinicians to identify painful spots and immediately evaluate the results of therapeutic interventions.⁽⁸⁾ Thermology has been used to obtain information about body temperature in clinical practice.^(9,10) It is used in medicine because of the low associated risks. This method detects the infrared radiation emitted by a surface to determine its temperature. It also enables capturing of thermal images from temperatures above absolute zero. Using thermographic inspection, different temperature distribution patterns can be observed to provide information about a normal or pathological process within an organism.^(11,12)

In clinical practice, it is necessary to improve knowledge about puerperal mammary glands, especially evidence-based quantitative data. Therefore, the aim of this study was to obtain scientific evidence of alterations in puerperal mammary glands based on clinical examination, pressure algometry, and thermography.

Methods

This descriptive and experimental study used a qualitative and quantitative approach. The study was conducted at a single time point at the Human Milk Bank in the City of Curitiba, Paraná. The sample included six lactating women, one of whom donated human milk and the other five of whom sought care at the Human Milk Bank.

Breastfeeding women were identified as (L1) lactating with flaccid mammary glands, (L2) lactating with mild glandular engorgement, (L3) lactating with moderate but non-obstructive glandular engorgement, (L4) lactating with moderate obstructive glandular engorgement, (L5) lactating with severe glandular engorgement, and (L6) lactating with flaccid breast (R) and mastitis (L).

As inclusion criteria, it was adopted volunteers with age ≥ 18 years, from the 10th to 45th postpartum day, with at least one volunteer in normal breastfeeding process and the others with any lactation-related abnormality. Exclusion criteria were a history of mammoplasty and/or breast implants; history of palpable or non-palpable breast lesion; history of lactational mastitis or altered tissue integrity in any region of the mammary gland; use of analgesics < 2 h before the study; and non-acceptance of the proposed method.

In this study, ME was classified according to the intensity of the signs and symptoms: flaccid breasts, one cross (+); mild engorgement, two crosses (++) , that is, swelling without discomfort; moderate engorgement, three crosses (+++) , that is, signs of heavy breast and pain sensations; and severe engorgement, four crosses (++++) , that is, heavy breast, stretched and red skin, and pain. The engorged area was also examined and graded

as follows: (1) lobular, milk stasis with pain and swelling in one or several sparse mammary alveoli; (2) lobar, milk stasis accompanied by pain in a group of alveoli, small ducts, ducts, galactophorous ducts, and lactiferous ducts; (3) ampullary, milk stasis restricted to the areolar edge, with or without pain; and (4) glandular, milk stasis in the entire mammary gland and pain sensations. Moreover, based on the literature and empirical experience of the evaluator, the resulting obstruction, that is, whether the engorgement was obstructive, was considered. In non-obstructive glandular engorgement, milk flows easily, whereas in obstructive glandular engorgement, milk does not flow or is released with great difficulty.

All tests were performed on frontal position with the lactating women seated, with the upper limbs aligned to the chest (Figure 1a).

After learning about the study and signing the consent form, the lactating women remained in a 7.5 m² area supplied with common air conditioning at a temperature of 23-24°C and relative air humidity of 40-50% measured by a digital thermo-hygrometer model 7465 (Incoterm, Brazil). The environment was protected from interfering heat sources or air currents and equipment that could have altered the temperature of the examination room.

The clinical examination was performed by a nurse with 15 years of experience in dealing with breastfeeding. Therefore, the data that supported the clinical diagnosis were collected by means of inspection/palpation.

To evaluate pain tolerance in the puerperal breast, the equivalent pressure was measured using a digital pressure algometer (FDI model; Wagner Instruments™, USA).

The pain equivalent to the pressure was measured in the four mammary quadrants (Figure 1c) using an algometer (Figure 1d) in kilogram force per square centimeter (kgf/cm²). The breasts were examined in quadrants: upper-outer quadrant (UOQ), upper-inner quadrant (UIQ), lower-outer quadrant (LOQ), and lower-inner quadrant (LIQ). These measurement areas were chosen as described in the literature, which indicates the

preponderance of certain mammary regions to develop engorgement.

The measurement started on the UIQ and proceeded clockwise to the left breast and counter-clockwise to the right breast. The evaluator used the verbal command “concentrate” and, with the tip of the algometer positioned orthogonally to the skin, applied pressure in a gradual and uniform manner. From the exerted pressure, the display of the instrument immediately showed the corresponding value. To verbalize their slightest discomfort to pressure, the volunteer was instructed to express the word “ouch” for the evaluator to immediately interrupt the pressure on the skin. In this moment, the algometer fixed the measurement on the display and registered the value corresponding to the lowest tolerance to pressure. Two measurements were taken for each quadrant and the average of both readings was used for the analysis.

The cutaneous temperatures of the lactating mammary gland in a normal scenario of engorgement or mastitis were measured using a thermographic camera (model A 325; FLIR Systems Inc., Sweden) (Figure 1a).

During thermography, the breasts remained uncovered for 15 min prior to the image capture. The thermographic chamber was placed on a 75-cm-high tripe at a distance of 130 cm from the lactating woman, and the captured thermograms included both breasts in a single image (Figure 1b).

The temperatures were evaluated in three distinct points distributed across the breast surface, where they presented the lower heat concentration (colder pixel). These criteria were adopted to avoid possible interference of the superficial veins in the analysis of the mammary gland since the peripheral blood circulation is more easily detected by thermography, which creates an obstacle for the investigation.⁽¹²⁾ Thermic symmetry was identified when there was a difference of <0.3°C between the breasts of the same woman, while thermic asymmetry was identified when this difference was >0.3°C. This threshold was based on results obtained from women during late pregnancy.⁽¹¹⁾

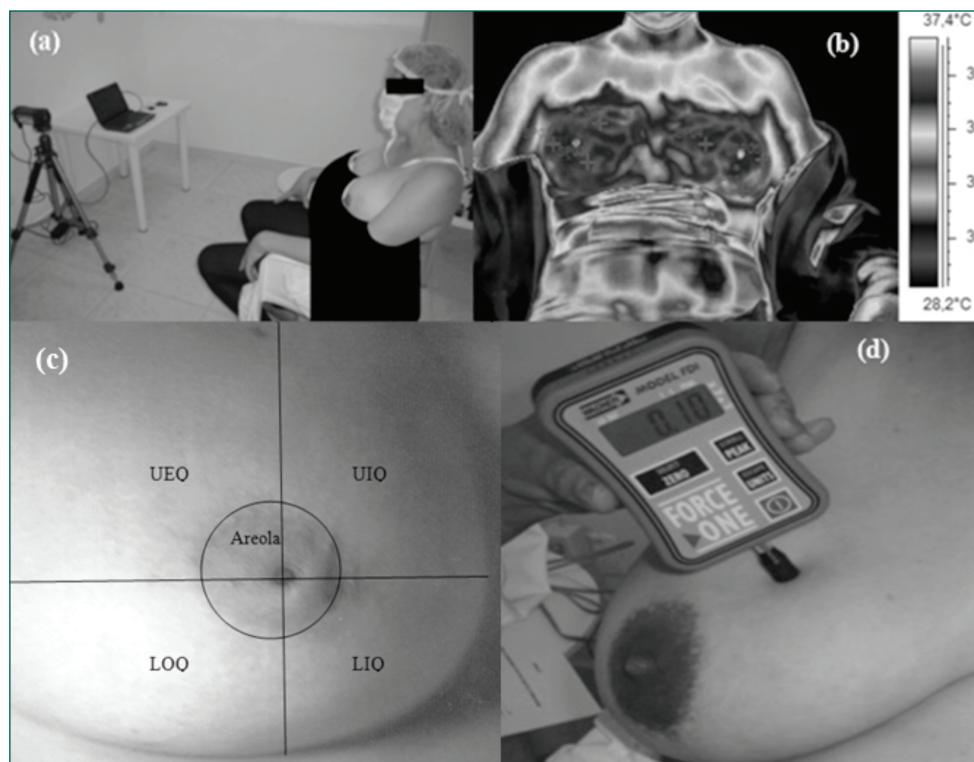


Figure 1. (a) Lactating woman during the acclimation period before image acquisition; (b) Thermography illustrating the temperature reading points. The marker, Flying spotmeter, and the Hainhi palette were used for the analysis. Here the thermogram has been recolored in grayscale; (c) Quadrants of the right breast illustrated by the authors. UOQ means upper-outer quadrant, UIQ means upper-inner quadrant, LOQ represents the lower-outer quadrant, and LIQ corresponds to the upper-outer quadrant; (d) Pain measurement using the digital pressure algometer FDI model (Wagner Instruments™)

The data were digitalized and analyzed using Microsoft Excel. The results obtained from the quantitative variables are expressed as averages, minimal and maximal values, and standard deviations (SD). ThermaCAM™ 2.9 (FLIR Systems Inc.) was used to analyze the images.

This study met the national and international ethical standards for research involving human beings.

Results

Palpation was used to identify engorgement intensity. Flaccid breasts were soft with no signs of engorgement, and manual pressing resulted in milk secretion. The breasts of volunteer L2 were mildly engorged, characterized by glandular swelling associated with diffuse engorgement throughout the mammary gland with a lacteous secretion. The

mammary glands of volunteer L3 were moderately but non-obstructively engorged with several lobes and moderately sparse engorged ducts throughout the breast, and manual pressure resulted in milk secretion.

The mammary glands of volunteer L4 were moderately and obstructively engorged, characterized by moderate swelling of the entire breast associated with edema and difficulty secreting milk. The lactating volunteer L5 had mammary glands with intense glandular engorgement and severe swelling. The right breast of lactating volunteer L6, who was diagnosed with mastitis, was completely flaccid. However, in breast E, with mastitis, the LOQ was swollen and red and had no fluctuation point (Table 1).

As shown in table 1, the flaccid breasts of lactating woman L1 presented the lowest temperatures (average 32.7°C), while the temperature of those of volunteer L6, who had mastitis, was the

Table 1. Lactating women classified according to physical examination (palpation), thermography (°C), and algometry (kgf/m²) findings of lactating mammary glands

Lacting	Physical examination				Thermography (°C)				Algometry (kgf/m ²)			
	Breast R	Degree	Breast L	Degree	Breast R	Breast L	Average	SD	Breast R	Breast L	Average	SD
L1	Flaccid	+	Flaccid	+	32.7	32.7	32.7	0.00	1.94	1.80	1.87	0.10
L2	Mild ME	++	Mild ME	++	34.1	34.7	34.4	0.42	1.21	1.27	1.24	0.04
L3	ME Moderate Non- obstructive	+++	ME Moderate Non- obstructive	+++	35.2	34.9	35.1	0.21	0.65	0.56	0.61	0.06
L4	ME Moderate obstructive	+++	ME Moderate obstructive	+++	34.5	34.9	34.7	0.28	0.40	0.38	0.39	0.01
L5	Severe ME	++++	Severe ME	++++	36.0	35.7	35.9	0.21	0.69	0.63	0.66	0.04
L6	Flaccid	+	Mastitis	++++	37.5	37.5	37.5	0.00	1.08	0.72	0.9	0.25

SD - Standard deviation

highest (average 37.5°C). The temperatures of the mammary glands with some level of engorgement were an average of 2.3°C (SD±0.65°C) warmer than the flaccid breasts of volunteer L1. Thermal asymmetry was seen between the right and left breasts (temperature difference > 0.3°C) in the four types of engorgement detected: mild ME, L2; moderate non-obstructive ME, L3; moderate obstructive L4; and intense ME L5.

According to laterality, a thermal symmetry (temperature difference < 0.3°C) was observed between the right and the left mammary glands of nursing women (L1 and L6). Among the lactating women presenting ME, the thermal asymmetry (temperature difference > 0.3°C) between the right and the left mammary glands was on average 0.6°C (SD±0.14).

The mammary glands with mild or moderate obstructive ME presented similar temperatures, with a difference of only 0.3°C, the latter being warmer. Compared to breasts with mild or moderate non-obstructive ME, a difference of 0.7°C was seen. An enhanced Haller network is observed in figure 1, with various points of anastomosis, especially in the mammary glands with non-obstructive moderate engorgement and those with severe ME. The breasts with moderate and obstructive engorgement, the most painful in the algometry tests, were 0.4°C colder than those with moderate non-obstructive engorgement.

It is noteworthy that, in the lactating woman with moderate obstructive mammary engorgement, Godet signs could be observed in the inferior portion of the left areolar region. In this mammary

gland, the lactating woman performed manual milk extraction 30 min before the image capture. The areolar region presented a qualitatively colder image than the same region of the right mammary gland. In the right breast, which was subjected to manual milk extraction 1 h before the image capture, no Godet signs were detected.

Among the mammary glands with moderate non-obstructive or severe engorgement, the temperature presented an average variation of 0.8°C, being warmer in severe ME.

The mammary gland with mastitis had a higher temperature, a difference of 1.6°C compared to the severely engorged mammary glands. It is important to note that volunteer L6 indicated that she had a fever a few days before treatment and had taken an antipyretic 2 h before the image acquisition. Therefore, it can be inferred that, due to the antipyretic, volunteer L6 would have had a higher body temperature than that measured during thermography, and that the right and left mammary glands would have presented with the same temperature.

The flaccid mammary glands from volunteer L1 were more tolerant to pressure (average, 1.87 kgf/m² ± 0.10 kgf/m²) than the breasts with a moderate obstructive engorgement (average, 0.39 kgf/m² ± 0.01 kgf/m²). The left mammary gland from L6 (with mastitis) tolerated a pressure of 0.72 kgf/m² (that is, 0.36 kgf/m² ± 0.25 kgf/m²), lesser than that tolerable by the healthy right breast. Among the lactating women with ME (mild, moderate, obstructive, severe), the pressure difference between the right and left mammary glands was an average of 0.02 kgf/m² ± 0.01 kgf/m². Among the flaccid

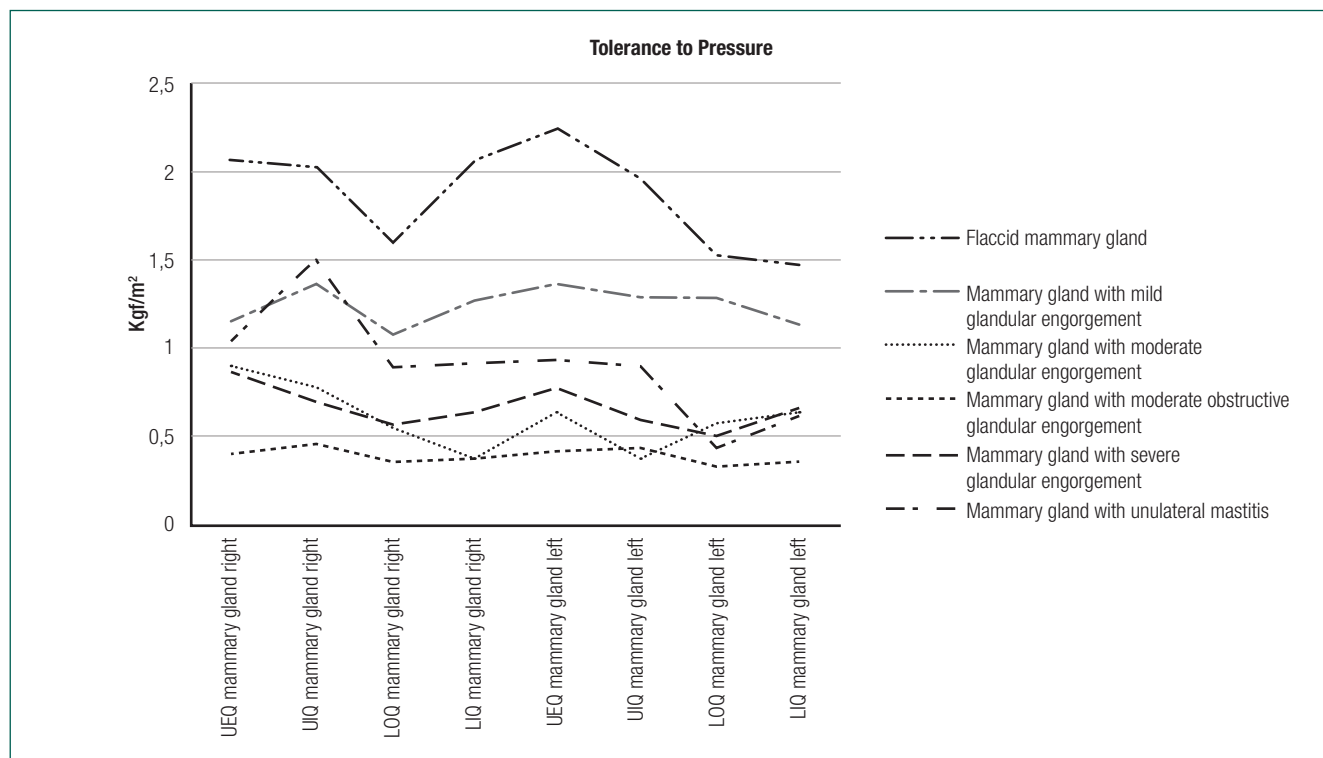


Figure 2. Tolerance to pain by quadrant and lactating mammary gland condition.

breasts (L1), the difference was $0.14 \text{ kgf/m}^2 \pm 0.04 \text{ kgf/m}^2$.

The LOQ of the right and left mammary glands generally showed a lower tolerance to pressure, followed by the UOQ of the right mammary gland and the LIQ of the left mammary gland. In the lactating woman with mastitis (L6), the affected left mammary gland was more painful than the right breast in almost all quadrants. The LOQ of this mammary gland was the most painful, explaining the degree of swelling at the critical point of the infection (Figure 2).

Discussion

The greatest difficulty of the developed experimental protocol was related to the time required for the acclimation since the breasts were kept uncovered for 15 min before the thermographic images were captured. This led to concerns about possible mood changes and hormonal alterations that are common during puerperium.⁽¹³⁾

In addition to physical discomfort, the lactating women presented with disrupted sleep and rest patterns due to caring for their newborns and the breastfeeding process. To minimize discomfort, the necessary acclimation period was used to clarify doubts about breastfeeding and for general advising.

The algometry and infrared thermography techniques used in this study are considered reliable since they have already been scientifically validated.⁽¹²⁾ These support evidenced-based practice⁽¹⁴⁾ since they enable our understanding of the mechanisms that promote breastfeeding and the scientific handling of human lactation.

The tolerance to pressure allowed distinguishing among the events that occur in the mammary gland during lactation since breast pain constitutes one of the most remarkable characteristics of ME.⁽⁵⁾ The algometry indicated that the LOQ was the most painful. However, no other study corroborates this finding.

Algometry is a semi-quantitative method that measures pain intensity and provides immediate re-

sults.⁽¹⁵⁾ Several factors can interfere with the results of this method, such as the consumption of alcohol or medicines that can mask the threshold of pain perception.⁽⁸⁾ For this study, majority of lactating women were in early puerperium (between the first and the tenth day after childbirth) and were using some type of analgesic. Therefore, we excluded volunteers who used analgesics in the 2 h prior to the study.

We observed that some of the lactating women were anxious and even distressed. In addition to the breast pain resulting from mammary engorgement or mastitis, the babies of some were hospitalized in the neonatal intensive care unit. We believe that these emotions may have affected pain tolerance in the algometry tests.⁽¹⁵⁾

Thermography is a method that captures the infrared radiation emitted by a certain surface to measure body temperature.^(12,16) On thermograms, differential patterns of temperature distribution are observed, which provides information related to a given process that is occurring within an organism.^(11,12)

According to the *International Academy of Clinical Thermology*,⁽¹⁷⁾ thermography is a comfortable and safe procedure. It contributes to evaluation of the vascularization of hard organs⁽¹⁶⁾ and pathologies of the soft tissues,⁽¹²⁾ thus functioning as an auxiliary component of the diagnosis.⁽¹⁸⁾ In addition to identifying thermal and vascular abnormalities,^(12,19) thermography is considered adequate for use in studies related to pain, which can be measured after therapeutic procedures for immediate evaluation or long-term treatments.⁽¹⁸⁾

In the engorged mammary gland, there is an increase in vascularization,⁽⁵⁾ accumulation of milk, and lymphatic and venous stasis.⁽⁵⁾ Physiological alterations have been detected using thermography, a proven method of physiological analyses.^(12,16,19) It is worth noting that the thermographic images in this study were not digitally processed for visualization of the inner anatomical structures of the mammary glands such as the ducts and milk-secreting alveoli. The evaluation of such a possibility would require further studies.

Thermography was considered an adequate methodology since it enabled the identification of

different patterns of thermal distribution between flaccid mammary glands and those with engorgement or mastitis. Therefore, thermic asymmetry between the mammary glands of the same woman was defined as a differential threshold of 0.3 °C.⁽¹¹⁾

The results of this investigation contribute scientific and technical knowledge from the development of innovative biomedical instrumentation. They also support the nursing practice in the clinical management of breastfeeding, especially in lactating women with mammary engorgement. However, these techniques require protocol improvement, and the sensibility thresholds and specificity to mammary glands require further determination.

Conclusion

These results indicate that the use of clinical examination, pressure algometry, and infrared thermography enables the delineation of differential patterns of pain and heat that affect the mammary glands in the lactating process and promote high-quality breastfeeding assistance. The techniques are easily performed, safe, innocuous, and well tolerated, although thermography requires an appropriate environment and an acclimation period.

The general application of the results discussed requires future multi-center studies with larger sample sizes to verify our results and enable the drawing of conclusions about the real effectiveness of the techniques.

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Collaborations

Heberle AB; Ichisato SM and Nohama P declare that they contributed to the conception of the study, analysis, data interpretation, writing of the article,

relevant critical review of intellectual content and final approval of the version for publication.

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